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for November, 1938

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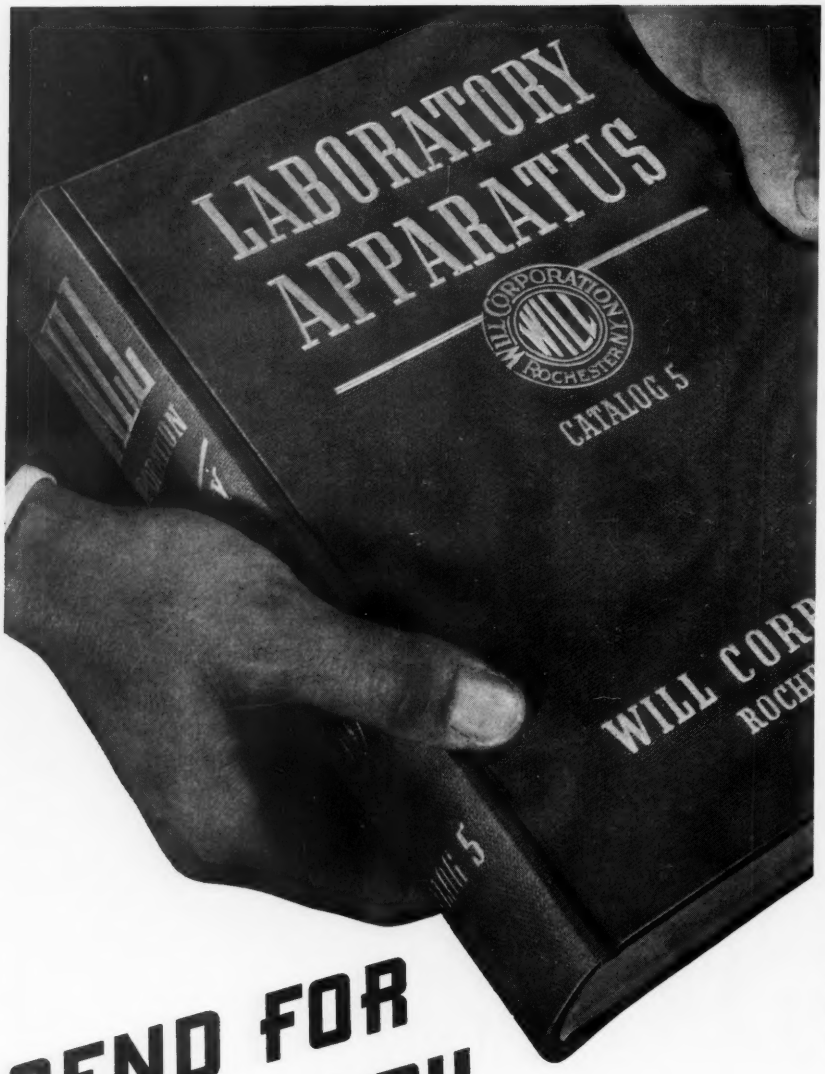

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JAMES R. PARTINGTON (1886–)

Few English chemists are better known to American students and teachers than James Partington, whose text-books on inorganic, physical, thermodynamics, higher mathematics for chemical students, and so forth, are widely used and respected. Born at Boulton in Lancashire on June 20, 1886, he showed an interest in chemistry at an early age, making experiments in a modest home laboratory. Later he took evening courses while working in a public analyst's laboratory. In 1906 he entered Manchester University, studied with Dixon and Perkin, and then did research with Lapworth. As 1851 Exhibition Scholar he spent 1911–13 at Berlin with Nernst, then returned to Manchester as assistant, lecturing on advanced physical chemistry.

In 1914 he entered the army as a private, later was commissioned in the Royal Engineers and saw service on the Somme. Recalled, he was assigned to the Munitions Inventions Department and took part in research on synthetic nitric acid.

In 1919 he was made professor of chemistry in East London (later Queen Mary) College in the east end of London. He still holds this chair, which is a professorship in the University of London. The college is in a poor district, the facilities for research are quite limited, but Partington has persisted in meeting these handicaps and together with his students has published some two hundred papers. The fields of work necessarily are adapted to the needs and facilities available, and comprise chiefly problems in thermodynamics, inorganic, electrochemistry, and dipole moments.

Dr. Partington's contributions to the literature of the history of chemistry include his outstanding "Origins and Development of Applied Chemistry" (1935) and his "Short History of Chemistry" (1937) based largely on original sources. He is chairman of the new Society for the Study of Alchemy and Early Chemistry. He is also chairman of the Publication Committee of the Faraday Society and associate editor of the *Journal of Physical Chemistry.*

(Contributed by Ralph E. Oesper, University of Cincinnati)

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EDITOR'S OUTLOOK

WE ASKED FOR IT. One reader has generously responded to our October editorial with a transmitting letter and a comment comprising six pages of single-spaced typescript, accompanied by various supporting exhibits. Regretful that we cannot publish his comment in full, we present the following condensation.

"On the editorial page of the October issue of the JOURNAL OF CHEMICAL EDUCATION, there appeared the amazing statement of attitude of the educational division of the American Chemical Society but concealed from those who may not stop to gather the concealed meaning. In one breath there is the invitation to members only for their expression of what, if anything, should be done by the MOST AUGUST society of American Chemists for High-School teachers, and in the next breath the implication is plain from the bold heading and following statements, that regardless of the expression of members or anyone else, all of which are no doubt considered inconsequential, THERE IS NOTHING THAT CAN BE DONE ABOUT IT (?), or, even if something could be done about it, we, as a purely scientific body, have no interest and perhaps no intention of doing anything about it. . . .

"Analysis shows that it is merely a matter of running true to old form, which is, what business or concern does the nationally *unknown* chemist have in the matter, so why be concerned about him, or even the future of chemistry as a profession, if it is one, and its relation to all human affairs, coördinating, correlating and coöperating in the proper way in the whole natural and social-economic scheme of things. It is presumed that the non-chemist is of no consequence to begin with. Well, well, where and when will chemistry become the cultural subject that it is so often considered to be by the manufacturers of Chemical Educational Medicine? . . .

"Now, if anything can be done and is to be done, it will have to be done by the leaders in chemistry, and it so happens that the leading chemists are also the chief leaders in the field of chemical education, and if there is reason for any education at all it is to benefit those being educated and in turn the whole people. Either we need education, or we do not need it, depending on whether we prefer a better self-governing democracy or one that is worse, or else autocracy, but do not forget that whatever we have in the way of government, we have it in everything, be it business, politics, society, science, education or religion. . . .

"Let us see if there are not a few things that can be found to be about helping the high-school teachers, who in turn will thereby do something for chemistry and for chemists. High school is the cradle of the chemist, and more people get a touch of chemical training there than ever follow it through, but its effects have a part in their future part in life. It is here that a beginning should be made in teaching the philosophy and ethics of any profession, and some of its business and legal aspects, and social-economic relation of chemistry to mankind, and to the chemist himself, because he must first learn to serve himself before he can serve others. He must be trained to see, know and do things scientifically with a full measure of remuneration but also with the true social and public spirit essential to a civilized state of existence.

"These things must be considered in the training of the masses as we do in America, and if chemistry is to be one of the subjects universally taught, then it cannot be alone for and in accord with the dictates of few chemical Royalists whose only desire is to stick tight to an already established place. Leaders like to criticize, but they never like to be criticized, but the editorial referred to expressed a slight desire to hear the opinion of the members, and this is one answer to the call. The entire editorial indicates the attitude of mind of too many leading chemists who care nothing for anyone other than themselves. . . .

"It should be the duty of the American Chemical Society, as a duty to the citizens of the nation, to point out a better course of study training from high school to and through the university, with the objective being to build a true profession of chemists, and to better the social and economic status of the chemist inasmuch as the chemist can only become an influential factor of the proper sort to society by better understanding of his place in society and the social-economic need for the chemist. Perhaps this need is not yet apparent to many chemists who are engrossed with their work, but to many outside of chemistry and to many chemists this is apparent. There is the same danger that the leading chemists, like the leaders in politics and business, will be too late in seeing the need for things today that become apparent tomorrow, after it is too late. . . .

"The editorial asked, what, if anything, can or should be done about it? There is a lot that can and should be done about it, in fact, must be done about it. Is the forest hidden behind the trees that the need for it cannot be seen? Do the chemists say, 'That is the headache of some one else, why bother us?' It begins to look as if we are to be the victims of the immediately past educational training methods and some of its poorly trained teachers and product of their class rooms.

"Here are some things that can be done about it. Work with book publishers, teachers and industrialists, engineers, economists, sociologists, and so forth, for fewer, better and proper textbooks. Please read the article in *The Engineer* for September 30, 1938, published in London, England, and found in all good libraries. The article title is 'Textbooks and Comments' by Wm. Bragg. Read the same journal for the past year for several good articles on training of professional men. The need is for books that have the least repetition, the clearest explanations with examples where needed. American teachers seem to want to teach theory when more practice work is needed. . . .

"The JOURNAL OF CHEMICAL EDUCATION can be made broader in that it should contain articles for other than chemists on any and all subjects available from sociology to engineering so that better correlation of science, industry, and government, and so forth, may result. If the Chemical Educational JOURNAL OF CHEMICAL EDUCATION thinks nothing can or should be done about helping the chemist then I shall cease to be a subscriber for it in the future. Writers for the American Scientific Journals fail to show much substance, in fact, some are plain silly in meaning, and many fail to show worthy convictions, and if they do, it is plain that too much value cannot be placed on the writers' convictions. They either prefer to be without convictions or else they are dominated by convictions for fear of calling a spade a spade. . . .

"It begins to look as if the need in America is for an Association for the Advancement of *Scientists*, rather than for the advancement of Science. Better things and better living through chemistry are not here yet for the chemist and his family. Perhaps he should do without a family. Now that chemists have helped us get contented cows, why not contented chemists? . . .

"Dr. Whitmore was not speaking idle words in his address before the Society in Milwaukee. The JOURNAL OF CHEMICAL EDUCATION intimates as much by saying that his questions are to be left open—yes, but not forgotten. They should be acted upon without delay. If immediate steps are not taken to act upon these questions, then most certainly they will be forgotten. Many educators like to start things, then see where they go with someone else to worry about the outcome. Now the big question before all of us is—where do we go from here? We are bound by the very nature of things to be on the way to somewhere, and what will the leaders do? They cannot take the attitude of not being bothered about a problem they may think some one else created, for they helped create it and now must help direct the monster. . . ."

CHANG TAO LING, *the* FIRST TAOIST POPE

ROY C. SPOONER*

West China Union University, Chengtu, China

TO CHANG TAO LING is given the credit for creating Taoism as an established religious movement. Because of this he is of interest not only to the student of the Taoist religion but also to the student of Chinese alchemy. For, by tradition, he is one of the few mortals who actually prepared the Golden Elixir and after partaking of it ascended to Heaven with his two faithful disciples, Wang Ch'ang and Chao Shêng to join the Immortals. In the early Lieh Hsien Ch'uan, the Biographies of the Immortals ascribed to Liu Hsiang (first century B.C.?) his name is not included. But in the Shên Hsien Ch'uan the Stories of the Immortals written by Ko Hung to supplement and complete the previous volume, his name is included. From that time to the present he has ranked among those who have obtained the Elixir and achieved the Tao.

Because of recent studies, great interest has been aroused in Chinese alchemy. Although Martin[1] some fifty years ago had emphasized its importance and had put forth the hypothesis that Chinese alchemy had a direct connection with that of Europe, yet little notice was taken. Today this hypothesis is accepted by Johnston, Davis, and other scholars.

The first mention of alchemical practice in Chinese history comes with the story of the efforts of Ch'in Shih Huang Ti (259–210 B.C.), the founder of the Ch'in Dynasty, to send an expedition to the Isles of the East, present-day Japan, and there secure "the drug that prevents death."[2] No mention is made of how the conception of this drug and its magic potency had arisen. Hence using alchemy to mean the use of chemical practices and knowledge to attain the Elixir†—one can say that here is no proof of any alchemy.

The second recorded instance of alchemical practices and belief is found during the Han Dynasty in the reign of the Emperor Wu Ti (140–86 B.C.). The Emperor is greatly enamoured of the possibilities of transmutation and it is recorded that definite experiments using cinnabar were performed.[3] However, even here no specific details are available. Huai Nan Tzu (died 122 B.C.), a contemporary of that time, has left writings which are steeped in language that may be alchemical in its meaning but again there is no evidence that the Elixir may be secured by chemical methods.[4]

CHANG TAO LING (BORN 34 A.D.) IS REPUTED TO BE THE FOUNDER OF THE TAOIST RELIGION. HE IS CREDITED WITH SECURING THE ELIXIR OF LIFE AND FLYING OFF TO HEAVEN WITH HIS TWO FAITHFUL DISCIPLES, WANG CH'ANG AND CHAO SHÊNG

* Present address: Graduate House, Massachusetts Institute of Technology, Cambridge, Massachusetts.

[1] MARTIN, W. A. P., "The Chinese," Harper & Brothers, New York City, **1881**, p. 472.

[2] FITZGERALD, C. P., "China," Gresset Press, London, **1935**, p. 221; WIEGER, L., "History of the religious beliefs and philosophical opinions in China," trans. WERNER, Shanghai, **1927**, p. 253.

† Alchemy is used as defined by Davis; see below for fuller description and reference.

[3] JOHNSTON, O. S., "Study of Chinese alchemy," Shanghai, **1928**, pp. 76–7.

[4] DAVIS, T. L., *Isis*, **24**, 327–40 (Sept., 1936).

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From this date we pass to Wei Po Yang the alleged author of the Ts'an T'ung Ch'i which was written about A.D. 142. This book, to quote Davis,[5] "is the earliest known treatise in any language devoted exclusively to the subject of alchemy." It is possible, however, that this is in reality a book on philosophy clothed in alchemical language. Our next writer Ko Hung (A.D. 281–261) gives us proof of a definite chemical and experimental basis that leaves no question but that he is a genuine alchemist.[6]

From the above outline it will be seen that Chang Tao Ling (born 34 A.D. (?)) is previous to Wei Po Yang, and inasmuch as he is the reputed founder of the Taoist religion, which is so closely linked with Chinese alchemy,[7] it would appear that a study of the materials available on his life should throw light on the relation between the two.

Efforts have been made to trace the origin of Chinese alchemy. Whence did it arise? Was it of indigenous origin, or was it imported from outside China, possibly from India, and then given its unique phraseology and place in Chinese cosmogony? In any case how is it related to the two basic conceptions that underly Chinese philosophy and thought, the Two Modalities, Yin and Yang and the Five Forces, the Wu Hsin? These are all questions of great importance.

The connection of Chinese alchemy with Taoism has been shown very clearly. Martin and Johnston have both demonstrated that in the conception of the Tao,* a fertile and stimulating impetus is found. Here is the creative idea that gave birth to the possibility of transmutation, first of mortal man into immortal, and second of base metals into precious metals. Martin believes "that Chinese alchemy had its root in the religion of the Tao."[8] Later, by his closing statement, he makes his meaning clearer, "alchemy is indigenous to China and coeval with the dawn of letters."[9] Here it is plain that what he means by the religion of the Tao is the Taoist philosophy of life which was so widely prevalent even before the writings of Lao Tzŭ (born 604 B.C.?) gave it its first written form, so that Chinese alchemy finds its roots within the earliest culture of China. Hu Shih mentions that alchemical practices were current among the coast peoples of north-east China before the Ch'in Dynasty.[10] Collier believes that the beginnings of Chinese alchemy can be traced back to the Chou Dynasty (1122–255 B.C).[11]

This theory of the very early origin of alchemy in China is different from that of Davis who says "alchemy appeared in China about the third century B.C. at a time when Taoism, which had previously been pure metaphysics took on magical and fantastic connotations and practices and became an important religion. Its objectives had a natural affinity with the aims of Taoism. Its followers were Taoists. Chinese alchemy seems to have been a spontaneous and indigenous growth conceived by the Taoists and nourished by them."[12] This difference in opinion is perhaps explained by the difference in definition of the word "alchemy." Davis defines alchemy "to be the search or the effort, whether successful or not, by chemical means to prepare a medicine of longevity or immortality, or by chemical means to prepare authentic noble metals from base metal or both, the pursuit of either or both of these objectives by chemical means. The beginnings of that search are the beginning of alchemy."[13]

Because of the close connection between Taoism and alchemy and since Chang Tao Ling is the person to whom is assigned the dubious credit of founding the Taoist religion, it is important to determine whether he had any definite conception of how to use chemical means to achieve the Elixir. Our evidence is scanty. However, two of the earliest records have been investigated and are reported below. Ko Hung, a prolific writer on all phases of alchemy, is assigned the authorship of the Shên Hsien Ch'uan, the Stories of the Immortals. In this text is given the biography of Chang Tao Ling. The translation by Mr. S. Wang and the author is as follows.†

Chang Tao Ling was a native of the P'ei Kingdom (present day Kiangsu) and had previously studied in the T'ai Hsüeh Academy.‡ He was very familiar with the Five Classics.** When he was an old man he sighed and complained "that this learning had been of little value to him in life." Because of this he studied the ways of achieving longevity and also succeeded in obtaining the Huang Ti Chiu T'ing Tan Fa.††† He wished to combine these two things. But to do this and so secure the Elixir required a great expenditure of money. His family had always been poor. He wished to make his living by farming or by being a herdsman but found that he had no ability for this type of work. So this method was given up.

He heard that the people of the land of Shu (Szechwan) were very simple and unsophisticated and were easily instructed. In addition, there were many well-known mountains. So he and his disciples went to Shu and took up their residence at Ku Ming Mountains. Here he wrote a Taoist book with twenty-four chapters. He also meditated in order to discipline his will.

Unexpectedly he perceived people from Heaven, descending in thousands of chariots drawn by innumerable horses, golden carriages with feathered covers, riding dragons and leading tigers in uncountable multitudes. Some of this group called themselves the Chu Hsia Shih;*** others were called the Cherubims of the Eastern Sea. They offered to Chang Tao Ling the new

[5] *Isis*, **24**, 338 (Sept., 1936).
[6] DAVIS, T. L., J. CHEM. EDUC., **9**, 517–20 (Sept., 1934).
[7] FITZGERALD, C. P., *loc. cit.*, p. 262; KOYANAGI, "Outline of Taoism" (in Chinese), Commercial Press, Shanghai, **1933**, p. 37.
* Tao may be translated as the True Path, the Way, the Principle, the Truth, the Logos, the Word, the Way of Life, the Absolute, the Primary Force.
[8] MARTIN, W. A. P., *loc. cit.*, p. 174.
[9] *Ibid.*, p. 193.
[10] HU SHIH, "Symposium on Chinese culture," Shanghai, **1931**, p. 42.
[11] COLLIER, H. B., *West China Border Research Journal* (in press).
[12] DAVIS, T. L., *Isis*, **24**, 327 (Sept., 1936).
[13] DAVIS, T. L., *Sci. Monthly*, **43**, 551–5 (1936).
† The copy translated was printed in Szechwan in 1894, and, as far as could be determined, is identical with the original edition.
‡ This was an ancient government school run for the sons of the nobles and equal in grade to a modern university.
** The Book of Change, the Book of History, the Book of Odes, the Book of Rites, and the Spring and Autumn Annuals.
††† The yellow Emperor Nine Tripod Elixir Method.
*** This was the official name given to the court historian. As Lao Tzŭ had held this office, it is here used to signify that they were followers of Lao Tzŭ.

charm that was called Chêng I Mêng Wei.* This he accepted and it enabled him to cure disease. Because of this, all the common people worshipped him and looked upon him as their Master. He had several tens of thousands of disciples. He immediately offered libations to the Spirits, and then distributed them among all the families.

Photograph by Courtesy of Museum of Archaeology, West China Union University, Chengtu, China

AN EARLY HAN DYNASTY (B.C. 206–25 A.D.) PIECE REPUTED TO HAVE BEEN USED IN PREPARING THE ELIXIR BY CHINESE SEEKERS OF IMMORTALITY. IT IS CALLED A T'ING OR TRIPOD

Regarding the officials, he set up certain regulations and ordered all his followers to carry these out. By turn they were to furnish rice, silk, implements, paper, pens, firewood, and other miscellaneous supplies to him. He made his followers repair the roads. Those who were unwilling to repair the roads, he caused to become ill. If a district had a bridge to be repaired, then all the people began to cut the grass and to remove all the obstacles. Everyone was eager to do this and only desired to carry out his will. However, the simple folk did not know this and so thought that the work was done by Chang Tao Ling himself. They thought that this work was done so that he could ascend to Heaven and descend again to Earth.

Chang Tao Ling also wished to use the principles of modesty and propriety to regulate the life of the people rather than punishments which he did not favor. So he set up regulations and ordered all the sick people to write a memorial giving complete accounts of their trespasses. These were to be written by themselves and thrown into the water so as to make an agreement with the spirits. They were not to violate the regulations again. If they did, they agreed to die. The people kept track of all those who recovered. If anyone suddenly became ill, he must first confess his sins, then he would recover. However, being deeply humiliated, he would not dare to again sin. In addition, fearing Heaven and Earth, the people reformed their behavior. So from this time on all the sinners became good.

Chang Tao Ling, therefore, received great wealth which he spent to buy drugs for use in preparing the Elixir. After succeeding in this task he drank only half of the dose as he did not wish to ascend to Heaven at that time. However, he was able to divide his spirit into many manifestations. In front of his dwelling place there was a pond. Chang Tao Ling often found relaxation in sailing. While so enjoying himself, Taoist priests and guests constantly filled his guest room. They perceived a Chang Tao Ling sitting there, talking, eating, and drinking with them. But the real Chang Tao Ling was all this time out on the pond.

He used the practices of the Yellow Emperor† and Lao Tzŭ to heal disease but changed their methods slightly—achieving, however, the same results. The control of the respiration,‡ the manner of clothing and eating, all are used in the methods for becoming an immortal. Chang Tao Ling's method was similar to these. He told his disciples, "You have too many vulgar customs; unless you discard these you can not leave this world behind, you can not receive my method for control of respiration nor can you understand the true principles of sexual intercourse** nor secure the method of using grass and wood to prepare a prescription which will give you several hundred years of life. The outline of the method of the Nine Tripods is to be given to Wang Ch'ang††† so that he may perfect his Tao. You will see a man arriving here from the east, at noon on the seventh day of the first moon." He also described his height and appearance.

At the stated time Chao Shêng arrived traveling from the east, his appearance and physical features were exactly as Chang Tao Ling had predicted. Chang Tao Ling tested him with seven temptations, none of which succeeded. After these, he gave Chao Shêng the Alchemical Classics. The seven temptations were as follows.

The first was when Chao Shêng came to visit Chang Tao Ling, he was refused entrance and the people were ordered to curse him. For more than forty days he slept in the woods nearby and did not go away. Finally he was granted admittance.

The second temptation was to order Chao Shêng to go into the grass lands to watch and drive away the wild animals. A very beautiful girl was sent to him. She pretended to be going on a long journey and asked for lodgings overnight. She shared his bed. The next morning she said that her foot was aching and so could not continue her journey. She stayed for several days enticing him. But Chao Shêng was entirely unaffected and retained his usual composure.

The third temptation was when Chao Shêng was on a journey he suddenly perceived thirty piece of gold. But when he came to them, he made no effort to pick them up.

The fourth temptation occurred when Chao Shêng was sent into the mountains to collect firewood. There three tigers kept crossing in front of him, biting at his garments but not harming his body. Chao Shêng was not afraid and his face did not change color. He spoke to the tigers thus, "I am only a Taoist priest. As a youth I did not do any evil so I have come more than a thousand Li in order to serve the immortal Master and secure the Tao of Longevity. Why are you doing this to me? Can it be because the mountain spirits have sent you to tempt me?" After some time the tigers ran away.

The fifth temptation happened when Chao Shêng bought on the market-place more than ten pieces of silk, for which he paid in full. However, the merchant accused him and said that he

* The name of a very famous, powerful Taoist charm.

† Very early legendary ruler (2698–2598 B.C.?)

‡ Great stress is put on this direct control of the respiration and breathing by the Taoists. The breath may be directed to various parts of the body and retained for some time.

** In sexual intercourse, the two principles of Yin and Yang meet and fuse, so giving an illustration of completeness and harmony that is thought to have a direct relation to the attaining of the Tao.

††† A very close and loyal follower of Chang Tao Ling.

had not paid over the money. Without changing his expression, Chao Shêng calmly took off his own garment and gave it to settle the account.

The sixth temptation was as follows. Once when Chao Shêng was watching the grain in the fields there came to him a man who kneeled, begging for food. His clothes were tattered and in rags, his face was dirty, and his body covered with sores and pus. His odor was very loathsome. Chao Shêng was moved and had compassion on him. He gave his own food to him to eat and in addition provided him with more from his private rice supply.

The seventh temptation was when Chang Tao Ling commanded all his disciples to climb above the steepest precipice of Yün T'ai Mountain.* Down below there was a peach tree shaped like a human arm growing on the face of the cliff and below it there was a bottomless abyss. The peach tree† was quite large and had peaches growing upon it. Chang Tao Ling said to his disciples, "To anyone who can secure these peaches, I will reveal the principles of the Tao." All the disciples kneeled down to look at the tree. Then the disciples, more than two hundred in number, trembled and perspired, but not one dared to even continue looking downward. There was not one who did not draw back and decline, saying that this was an impossibility. Only Chao Shêng, this one person said, "For those whom the spirits protect, there is no danger. The Holy Master is here with us and will not allow me to die in the abyss. The Teacher wishes to use this to teach us a lesson... this is why the peaches must be secured." For these reasons, he then threw himself over the cliff onto the tree. His feet did not slip, nor did he fall down. He plucked the peaches, using his gown as an apron to hold them. The cliff was so steep and dangerous that he was unable to climb back. So he took the peaches and one by one tossed them up. He actually secured more than two hundred of them!

Chang Tao Ling caught them and distributed them among his disciples, giving one peach to each person. Chang Tao Ling himself ate one and left another for Chao Shêng. He then used his hand to pull Chao Shêng up. The group all noticed that Chang Tao Ling's arm became twenty to thirty feet long in order to assist Chao Shêng. Chao Shêng suddenly reappeared and was given the remaining peach. After he had finished eating it, Chang Tao Ling approached the cliff and jokingly said, "Chao Shêng has indeed a pure heart for he was able to cast himself onto the peach tree without his feet slipping or falling. Now I certainly should be able to throw myself down and secure some really large peaches."

The crowd all remonstrated with him, only Chao Shêng and Wang Ch'ang keeping silent. Chang Tao Ling cast himself into the air but did not fall onto the tree. His whereabouts were unknown. They looked in all directions, upward in the sky, downward into the bottomless abyss but there were no roads visible. They all were frightened and sighed and cried sadly. But Chao Shêng and Wang Ch'ang, after some time, said to each other, "The Master is our father; he has cast himself over this vast immeasurable cliff. How then can we be happy without him?" They then threw themselves over the cliff and landed in front of Chang Tao Ling who was sitting with his feet crossed and his arms folded in his place of meditation. When he perceived Chao Shêng and Wang Ch'ang, he laughingly said, "I knew that you would come." He then completed instructing them in the Tao.

After three days they returned and set in order their previous places of residence. All the disciples were greatly frightened and cried without ceasing. Afterward the three of them, Chang Tao Ling, Chao Shêng, and Wang Ch'ang, at midday flew up into the heavens with all the disciples gazing after them. After a long while they disappeared among the fleecy clouds.

When Chang Tao Ling first entered the mountains of Shu, he took half of the complete Elixir. Although, at that time he did not ascend to Heaven, he had already become the Earth Spirit. It was his purpose to stay and use these seven temptations in order to test Chao Shêng and afterward release him from this world.[14]

From the picture here presented by the alchemist, Ko Hung, it is clear that no proof or even statement is presented that Chang Tao Ling was an alchemist. No mention is made of any chemical or chemical method used by him.‡ There is mention of the Elixir, but the disciples are shown as being able to receive its benefits largely by reason of their perfect way of life, their self-control and loyalty to the Master. It is the perfecting of one's Tao that is sought rather than the Elixir.

A study of the biography given in the Lieh Hsien Ch'uan, the Biographies of the Immortals,** which is a fairly recent semipopular treatise, gives an even more highly colored picture of the miracles performed by Chang Tao Ling. In this account the secret of the Elixir is found in a buried book. But again there is no mention of any specific chemical or chemical method employed.

The Official History of the Later Han Dynasty has this to say regarding Chang Tao Ling, " . . . . . The following year, Ts'ao Ts'ao badly defeated Chang Lu and conquered Han Chung (a district in northeastern Szechwan). Chang Lu's other surname was Kung Ch'i. His grandfather Chang Ling, in the reign of the Emperor Shun Ti (A.D. 126–144), had previously traveled to Shu (Szechwan) and resided on Hao Ming Mountain where he studied how to perfect his Tao and wrote books on charms to deceive the people. All those who became his followers had to contribute to him five bushels of rice. Because of this he was called 'rice-thief.' Chang Ling bequeathed this Tao to his son Chang Hêng who later transmitted it to Chang Lu."[15]

In evaluating this passage and one other in this same source, giving the same story, it must be remembered that it was written by court historians who would be Confucian in outlook and naturally not favorable to anything of an unorthodox nature, such as a semisecret society which might prove to be a potential menace to the government. Later, groups similar to this group, and said to be directly related, rose in rebellion and proved difficult to suppress, confirming the fears of the historians.[16]

The comments of Wieger on this episode are most interesting. He mentions that this text dates from the third century and so is almost contemporary, and that it "throws a clear light on the political evolution of Taoism, on the way that the Taoist leaders took to

* A mountain in northeastern Szechwan (?).

† The peach was the fruit that signified longevity.

[14] For another biography of Chang Tao Ling *cf.* WERNER, E. T. C., "Myths and legends of China," Brentano's, Inc., New York City, **1922,** pp. 138–42, 216–7.

‡ Among the books of alchemy of the Taoist Classics, there are at least seven essays under the name of Chang Tao Ling. Among these there is mention made of some common chemicals. However, it appears extremely unlikely that these were actually written by Chang Tao Ling. Further investigation is needed on this point.

** This should not be confused with the book of the same name ascribed to Liu Hsiang. Neither is it similar to the Lieh Hsien Ch'uan Ch'uan, the Complete Records of the Immortals, sections of which have been translated by Wu and Davis.

[15] "Hou Han Shu," section 105, p. 2.

[16] WIEGER, L., *loc. cit.*, p. 378.

exploit the latent superstition of the Chinese people, a superstition which causes that immense mass to be always ready to become inflamed and to explode." Wieger, in addition, adds, "the rather obscure life of Chang-ling was later embellished by legend ..... They pretend that Lao-Tzŭ appeared to him in person, that he found the drug of immortality, that he took up his abode on Mount Lung-hu (dragon-tiger) in the present Kiangsi and finally that he ended by ascending alive to heaven."*

The headship of this new sect was a continuous one and is said to have been unbroken down to a few years ago. By his writings Ko Hung undoubtedly had a great influence in popularizing Taoism and giving it an alchemical and magical twist. Later the head of the Taoist religion was officially recognized by the State and the title of T'ien Shih or Heavenly Master bestowed upon him and his successors.[17] This title was abolished by the Republican Government shortly after the 1911 Revolution. From this has come the title of "the Taoist papacy," which claimed Chang Tao Ling as its first "Pope."

In view of the preceding, it would appear that Chang Tao Ling was not an alchemist, nor was he noted for his knowledge of chemical methods that could be used to obtain the Elixir. Rather he seems to be the representative of the "wu group of magicians and wizards[18] or Fang Shih. These groups have a history stretching back into the Chou Dynasty or earlier. They represent the earliest religious ideals of the Chinese people. Collier[19] quotes several sources to show that among this group, at an early time, there was the conception of obtaining immortality by the eating of certain drugs or by magic practices. These groups had not been eliminated by the rise of the philosophies of Lao Tzŭ or Confucius but were at this time actively borrowing certain features of Taoist philosophy and combining it with their own beliefs and magic practices, so forming the new religion of Taoism.[20] This is the explanation for the wide gulf that is found between the Taoist philosophy and the Taoist religion. It is interesting to note that even today there are a few distinguished representatives of this type of magic. Just a few years ago, the late General Liu Hsiang, at that time the war-lord of Szechwan, had as his most important adviser in all matters a Taoist priest who was noted for his prophecies and magic works.

We would conclude, then, that Chang Tao Ling was a representative of this group of magicians. As such he probably possessed the belief in the Elixir of Life, but the method to be used to obtain it would not depend essentially on chemical knowledge or practices. Hence he cannot be called an alchemist. Nor has definite proof been found to show that there was any direct connection between alchemy and the Taoist religion at the time of the latter's inception.

* Also said to have taken place at the Azure City Temple, a most beautiful Taoist temple near Kwanhsien in Szechwan. One section of the temple is called the Cave of the Heavenly Master and features a cave in the mountain where Chang Tao Ling is said to have actually lived.

[17] COULING, S., "Encyclopedia sinica," Oxford University Press, London, **1917,** p. 340.

[18] FITZGERALD, C. P., *loc. cit.*, pp. 44, 218, 221, 261.

[19] COLLIER, H. B., *loc. cit.*

[20] KIANG KANG-HU, "Chinese civilization," Shanghai, **1935,** pp. 321, 326–7.

The GOLD CONTENT *of* SEA WATER

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GOLD is conceivably present in sea water in one of the following states: auric or aurous ion, colloidal gold particles, gold entrained in or comprising part of suspended rock particles, organic gold-containing matter. Numerous investigators have analyzed sea water for its gold content, and much variance is noted in their reported results. Nearly fifty patents on methods of securing gold from sea water are on record as from several countries. Fraudulent promoters, or overly hopeful persons, have many times organized companies and sold stock therein, which companies, it was speculated, were to profitably extract gold from sea water. The author proposes to review some experimental work of past investigations on determination of gold in sea water and to report some recent work on analysis for gold in sea water off the Northwest Coast of the United States.

A brief résumé of some of the patented methods for recovery of gold from sea water is as follows:

(*a*) Filter sea water through charcoal, leach charcoal with KCN solution, recover gold by use of zinc or electrolysis.

(*b*) Reduce dissolved gold by such substances as sulfur dioxide, hydrazine salts, or hydrogen sulfide, follow with filtration.

(*c*) Beat quicksilver through the water as a gold collector.

(*d*) Use some collectors such as powdered copper,

iron oxide or hydroxide, or organic semicolloidal substances, prior to filtration.

(*e*) Dissolve some copper salt or lead salt in the gold-bearing sea water, add H_2S or Na_2S to obtain finely divided CuS or PbS which adsorbs the reduced gold; the precipitate may then be filtered or centrifuged from solution.

(*f*) Use finely divided sulfur or polysulfide plus acid for reduction and adsorption of gold from dilute solution.

(*g*) Electrolyze sea water, using low voltage (possible use of high speed rotary cathodes).

No method has met with any commercial success. The successful economic processes of recovering bromine and magnesium compounds from sea water, and the increase in price for gold, have somewhat stimulated thought of obtaining gold from sea water. Investigation of the most accurate determinations of gold in sea water, however, discourages the idea that economic recovery of gold from the vast oceans is near at hand.

Svante Arrhenius (*1*), about the year 1902, was interested in gold in sea water and reported analysis to indicate sea water contains 6 mg. Au per metric ton. This figure is considerably lower than that of 65 mg. per metric ton reported thirty years earlier by E. Sandstadt (*2*).

The experimental results of several contemporaries of Arrhenius seemed to approximately corroborate his work, but considerable variation in their estimates is noted.

Chr. A. Munster (*3*) evaporated one hundred liters of sea water to dryness. He then reports analyzing 1.8 kg. salts to finally estimate 5–6 mg. of Au per metric ton of sea water. J. W. Pack (*4*) records an average of 30 mg. Au per metric ton of ocean water; J. R. Dan (*5*) claims recovery equivalent to 4–5 mg. Au per metric ton of sea water; L. Wagoner (*6*) reported 11–16 mg. of the noble metal per ton of sea mud.

The methods of analysis used by these investigators embody the chemical methods of recovery of Au from dilute solution as listed above. The outstanding analytical work for gold content of sea water was done by F. Haber (*7*) and his co-workers. A quite recent review of his work is given in an article by J. Jaenicke (*8*).

During the war period Haber developed a synthetic nitrogen-compound industry for his country and tried to bring his people victory by aiding in the introduction of gas warfare. After the war he sought to solve their financial ills and war debt burden by tackling the gold from sea water problem. His researches on this problem extended over a period of ten years, and entailed collection of samples of water from such diverse places as the Rhine, the North Sea, North Atlantic, San Francisco Bay, and the South Pacific. Samples at varying depths and at different seasons were taken. Polar sea ice was sampled for gold analysis.

First rough results seemed to check those of earlier observers of a gold concentration of 5 mg. per cubic meter of open sea water. Several methods of gold recovery were used on actual sea water and on simulated sea water with a known amount of gold added. By bubbling SO_2 through synthetic sea water, followed by filtration, but thirty-five per cent. recovery of added gold was attained. Somewhat better results were had by adding to the water lead acetate or mercurous nitrate followed by ammonium sulfide. The metal sulfide formed acts as a noble metal collector and this filtered metal sulfide can then be assayed.

As Haber became more exacting and painstaking in his analytical work, his results as to amount of actual gold in sea water became lower and lower. He developed assay technic that had never been equaled. Lead or mercury-containing chemicals were highly purified. Even the probable minute gold content of cupels was considered. An accuracy of ± 3 per cent. on amounts of gold from solutions containing as little as 1×10^{-8} gram is claimed for his developed procedures.

As translated from Jaenicke's paper (*8*). . . . . "As satisfying as these improvements in methods of analysis were, just so disappointing was its reaction on the main problem. For it seemed as if the gold content in the bottle tests fell with every step which was taken forward in the conquering of difficulties of method—and in the course of years the micrograms of Au per liter of sea water became tenths and hundredths of micrograms, finally only to end at millimicrograms. Here the matter has remained, and will presumably remain, as a sign that the deceptively high values of the beginning work were scarcely real and owe their short-lived apparent existence only to accumulation of from reagents and cupels used gold in analysis.

"To be sure the amount of gold in the world seas, even after Haber has placed the true figure at thousandths of milligrams instead of whole milligrams per ton, there still remains a very great amount of gold in the ocean which exceeds by a few powers of ten the whole amount of gold mined and recovered in historical time. The desire to recover it for itself alone will have to remain a vain undertaking for unbounded time because every process for getting the gold would destroy many times that amount or its equivalent."

Mataichi Yasuda (*9*) developed a method for determination, by recovery means, of minute amounts of gold and silver from solution. The gold content of water in three Japanese bays is reported by Yasuda as being 3, 10, and 20 mg. per metric ton. These results are, again, much higher than those of Haber.

Since there is a need for more exacting methods of determination of minute amounts of gold and silver in mine waters, ore leach solutions, and various noble metal-bearing solutions, the author and co-workers (*10*) have elaborated on procedures of Yasuda and of Haber. Having developed a process for treating very much larger samples than had heretofore been examined, it was of side interest to our main problem of determining gold and silver in commercial solutions to ascertain the gold content of sea water off the northwest coast of the United States. Would the results correspond with

those of Yasuda on Japanese bay waters or with the thousand times lower results of Haber?

Samples of ocean water were procured in forty-liter carboys from several Oregon and Washington beaches. These samples were collected from surf into glass carboys or by bucket and rope from a pier, water being poured into carboys. Samples from various depths and places in Puget Sound were obtained on voyage of University of Washington oceanographic boat "Catalyst." From the deck of the "Catalyst" one hundred twenty liters of sea water was hauled up by use of a silvered twenty-gallon depth bottle, from one hundred eighty meters depth in the middle of the Straits of Juan de Fuca.

To the forty-liter samples were added 400 ml. of 0.1 *M* $HgCl_2$ followed by 40 g. of Mg powder and 400 ml. of conc. HCl. The nascent hydrogen from the action of acid on metal reduced $HgCl_2$ to yield a semi-colloidal Hg–HgCl precipitate. As this Hg–HgCl precipitate slowly settles to a compact residue in the bottom of the carboys, it collects any noble metal present from solution. The bulk of the water may be siphoned from the residue; the residue is then filtered and is ready for fire assay for its gold content.

Very pure test lead is mixed with the residue, a 10-mg. piece of silver is added, and the whole placed on an assay cupel. After heating in furnace to volatilize lead and mercury compounds, a silver and gold bead is obtained. The silver is parted from the gold with dilute HNO_3. The minute particle of gold that remains undissolved in the parting crucible is heated to redness to anneal and collect the spongy gold. Weighing is accomplished on an assay balance of 0.002 mg. sensitivity.

The obtaining of 0.002 mg. of Au from a forty-liter sample is recovery of one part of gold from twenty billion parts of water.

Table 1 lists results of analysis upon some of the samples analyzed. To be certain that chemicals in sea water were not inhibiting recovery of gold by the method used, known amounts of gold chloride were added to samples of sea water and analysis made thereon. A high percentage of gold recovery was had therefrom.

In the reported works of Haber and others, tables are quite elaborate as to time (day, hour, minute), place (latitude, longitude, depth) and other information as to sample taking. A few years later it is acknowledged their analysis were about 10^n times too high as to Au content of sea water. We merely acknowledged our results on sea-water analysis as giving a maximum for gold content with probability of less actually present, being led to this statement since all micrograms of Au cannot be removed from recovery and assay chemicals. Knowing that even our determinative method for such minute amounts of Au in water cannot be relied on to differentiate between probable place and time variation of sea water gold content, we did not elaborate our table with such figures.

DISCUSSION

These results seem to parallel those of F. Haber as against those of investigators who used less accurate technic and may have had gold contamination from chemicals used, and who report higher Au content for sea water. The method of collecting gold from the forty-liter samples herein reported is an improvement over the method of F. Haber. The fire assay part of the procedure was not carried out with as exacting detail as to chemical and cupel purification as done by Haber. It is desired then that these results be considered as maximum values for Au content of sea water with the real value perhaps somewhat lower.

TABLE 1

GOLD CONTENT OF OREGON COAST AND PUGET SOUND SEA WATER

Source of sample	*Date obtained*	*Vol. liters*	*Gold recovered, Mg.*	*Gold per metric ton, Mg.*
1. Waconda Beach	October, 1934	40	0.010	0.26
2. Waconda Beach	October, 1934	40	trace	—
3. Waconda Beach	October, 1934	40	0.012	0.30
4. Puget Sound, University of Washington storage tanks	November, 1934	40	trace	—
5. Puget Sound, University of Washington storage tanks	November, 1934	36	trace	—
6. Puget Sound, Richmond Beach	November, 1934	50	0.004	0.08
7. Puget Sound, Richmond Beach	November, 1934	47.5	0.004	0.08
8. Waconda Beach	December, 1934	40	0.008	0.20
9. Waconda Beach	December, 1934	40	0.008	0.20
10. Waconda Beach	December, 1934	40	0.010	0.25
11. Waconda Beach	December, 1934	80	0.014	0.175
12. Straits of Juan de Fuca, Cllalam Station 180 meters depth on "Catalyst"	March, 1935	40	0.015	0.375
13. Straits of Juan de Fuca, Cllalam Station 180 meters depth on "Catalyst"	March, 1935	40	0.040	1.00
14. Puget Sound surface on "Catalyst"	March, 1935	80	0.008	0.10
15. Puget Sound surface on "Catalyst"	March, 1935	40	trace	—
16. Puget Sound surface on "Catalyst"	March, 1935	40	trace	—
17. Puget Sound	March, 1935	40	0.010	0.25
*18. Agate Beach sea water	plus 0.235 mg. Au	10	0.23	—
*19. Agate Beach sea water	plus 0.010 mg. Au	10	0.006	—

* Sea water plus added $AuCl_3$.

The gold beads obtained from forty liters of sea water are so small as to be near the limit of accuracy of an assay balance in their weight. They are so small that they are easily lost and usually require a lens to be readily seen. Blank runs to verify chemical purity gave blank or trace amounts of gold, except for a few cases in which minute beads were obtained. A small bead was recoverable from all sea water samples except those samples where organic matter had probably already precipitated gold from solution. There was a small amount of organic residue on the bottoms of the sea water tanks in the University of Washington Oceanographic laboratory, and little or no gold was obtained from samples of water from these tanks.

Since the gold content of sea water is shown to be down near the limit of accuracy of our determinative method on forty-liter samples, and since it is easily conceivable to have 0.005 mg. of gold from even test lead, cupel material, and so forth used, it is merely concluded that there is a maximum of about 0.1–0.2 mg. of gold per metric ton of Oregon coast or Puget Sound sea water. At $35 per ounce, one milligram of gold is worth approximately $0.001. Thus it is indicated that there is less than $0.0001 of Au per metric ton of sea water. It does not seem economically feasible to extract the one-hundredth cent worth of gold or less from a metric ton of sea water.

Our figures for Au analysis of sea water verify results of F. Haber against investigators using less accurate technic or method. The amount of Au in sea water is not nearly as great as reported in most texts or in popular literature.

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CLINICAL CHEMISTRY

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INTRODUCTION

THE past two decades have witnessed rapidly expanding applications of the discoveries and technical developments in the exact sciences, particularly chemistry, as aids to medical practitioners.[1] In this development, the clear distinction between the objective investigations of the scientist and the subjective utilization of the fruits of his investigations by the physician should be apparent. Nevertheless, considerable confusion has arisen. Clinical chemistry has been called into question and with it the whole profession of chemistry.

What is a clinical laboratory?
What is a technician?
What is a clinical chemist?
Should a clinical laboratory be conducted like one for commercial testing? If not, what limitations should be put upon it and why?
Is chemistry a profession?

The nature of some of these questions indicates the depth of the confusion.

[1] " . . . there is hardly a branch of medicine or surgery which does not, at some time, have need of the information which can be supplied by the biochemical laboratory;" STEWARD, C. P. AND DUNLOP, D. M., "Clinical chemistry in practical medicine," William Wood & Co., Baltimore, **1937**, preface, p. 5.

FROM RESEARCH LABORATORY TO MEDICAL DIAGNOSIS—VIA THE CLINICAL LABORATORY

In the normal course of advancement of science the developments of the research worker ultimately find practical application. This is as true in research work related to medicine as it is in research work related to industrial applications. New concepts of the research worker eventually are reduced to routine use in the laboratory. In the chain of events which takes place from the time an idea destined to be useful in diagnosis is conceived in the mind of the research worker to the time when it is made available for the medical practitioner, it is the clinical laboratory which functions as the last link. Once the clinical laboratory has done its work and passed its results on to the physician, who applies them as part of his diagnostic picture, the research worker's idea had passed into the realm of medical practice.

The line which separates laboratory investigations that enter into a medical diagnosis from the diagnosis itself is perfectly clear. On the one side, in the laboratory, we see objective determinations of physical and chemical facts derived from the use of the familiar tools of the laboratory and the skill of the investigator. On the other, in the physician's office, these facts, when

integrated by him with all other clinical factors, result in a medical diagnosis.[2]

A clinical laboratory, then, may be defined as "A laboratory for the practical application of chemistry and the other fundamental sciences wherein are made such factual investigations for the physician as he may desire in the study of his patients."

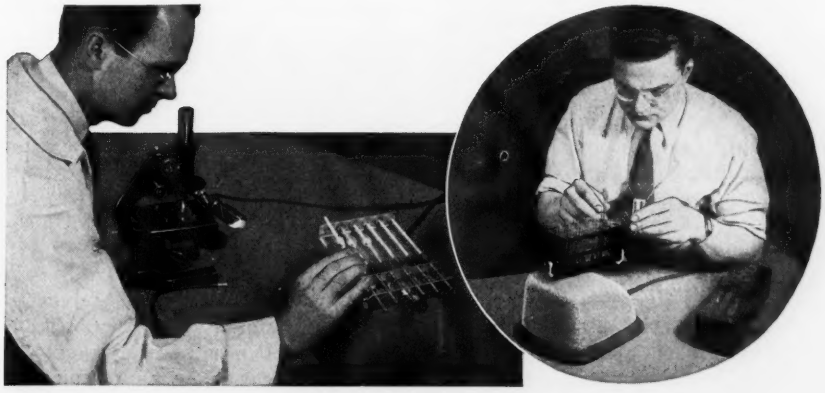
TECHNICIANS

Many physicians do simple laboratory tests themselves; for example, boiling urine for albumin and sugar. Some go further and establish laboratories in their offices where, mostly with the assistance of technicians, slightly more advanced laboratory investigations are carried out. These tests usually embrace microscopic urinalysis, blood counts, and simple blood chemistry.

With the passage of time this practice has become general. A large body of semiskilled laboratory workers, called "technicians," has come into existence. This group, almost one hundred per cent. feminine, performs at least seventy-five per cent., possibly as much as ninety-five per cent., of the actual work in the clinical laboratory today. While some technicians are highly trained, many have little more than a high-school education. Like the laboratory assistants in the testing laboratory of industry and commerce, they perform useful, even indispensable functions, when working under the constant supervision of one versed in the fundamentals of analysis. Without such supervision they may, and frequently do, fall into gross error.[3] A

[2] "The following conditions may be laid down as necessary precursors to arrival at an intelligent diagnosis: *On the Observational Side.*—(1) An accurate history of the patient, including the age, sex, race, civil condition and occupation, and an account of the present and past illnesses, the habits, the surroundings and the family tendencies. (2) A systematic and painstaking physical and mental examination. (3) A record of such laboratory findings or technical procedures (X-ray, electrocardiograph, basal metabolism, Wassermann reaction, etc.) as may bear on the case. *On the Inductive Side.*—(1) A working knowledge of normal and abnormal function and structure and of the interpretation of laboratory and technical tests. (2) A knowledge of the diagnostic possibilities, *i.e.*, the ability to call to mind the diseases which must be considered as possibilities in a given case. (3) A realization of the presence of a diagnostic problem. (4) The ability to weigh and evaluate the observed facts in the light of the diagnostic possibilities and to reason from them to a logical conclusion." BLUMER, G., "Bedside diagnosis by American authors," W. B. Saunders & Co., Philadelphia, **1928,** pp. 2–5.

[3] "It is abundantly clear that the Wassermann technician must carry out daily a series of mechanically simple procedures. It is entirely possible to learn these by rote, in which case the work of the laboratory may proceed quite smoothly for long periods of time, until inevitably something goes wrong. It is then that the automaton, who, however careful, follows prescribed directions mechanically, becomes hopelessly lost; and the results obtained become worthless, because of either false negative or false positive results. In every Wassermann laboratory there should be at least one person, thoroughly conversant with the principles of the reaction, the properties of the reagents, and the innumerable sources of error or variation inherent in the technic." EAGLE, H., "The laboratory diagnosis of syphilis," C. V. Mosby Co., St. Louis, Missouri, **1937,** p. 139.



technician, as that term is used to refer to this class of workers in clinical laboratories, may then be defined as a person possessing the manipulative dexterity to carry out competently, although mechanically, the technical operations of the clinical laboratory. To the extent that the technician acquires understanding of the fundamental scientific base of the work done and of the pitfalls involved, he or she tends to rise above the technician class.

THE CLINICAL CHEMIST

Clinical chemistry has been defined in standard medical dictionaries as "chemistry applied to medicine." The term is broad, including in its province the work of all types of men, from those whose discoveries in the field of biochemistry are revolutionizing our concept of life processes, to those who apply their collegiate training to the determinative field of the clinical laboratory. At the higher levels of the term brings to mind names like Folin,[4] Van Slyke,[5] and others. At its lower extremes it may include a few whose qualifications are little above those of the better trained technicians. In general, however, it may be fairly stated that clinical chemists possess professional qualifications of the same high caliber as those of chemists in other fields.

The clinical chemist must be well grounded in the fundamentals of qualitative and quantitative analysis, and must also have specific knowledge of the peculiarly exacting problems of his special field. Working continually with small amounts of materials and with little opportunity for duplicate determinations, he constantly checks his standards and measuring instruments, to guard against insidious errors. He devotes whatever time he can spare from his remunerative labors to research work, and reports his findings to his colleagues, for the advancement of their special branch of science.

The practice of clinical chemistry involves the examination of the blood, the urine, and the various secretions of the human body. The work differs from ordinary commercial testing in that, for the protection of the public, the report of his analysis is always withheld by the chemist from the person whose specimen he examines. Instead of reporting to that person, the chemist always sent his results on specimens of this type to a licensed practitioner of the healing arts. The necessity for protecting the public against the consequences of attempting self-treatment may be illustrated by an actual occurrence.

Several years ago, a physician asked the writer to determine the blood sugar level in a person suspected of diabetes, who was suffering with gangrene of one leg. On arrival at the person's home to obtain the specimen, I was shown a stack of urinalysis reports covering a period of five years, signed by a man who termed himself a "chemist." These were uniformly negative for sugar. The person's blood sugar was found to be very high. The man's leg had to be amputated as a result of the neglect of his constitutional condition.

The responsibility here clearly rested with the laboratory which had sent its reports directly to the ailing man instead of insisting that they be sent to a practitioner of the healing arts. For five years this sick man had been relying solely on urinalysis reports and had been deprived of the ministrations of competent physicians.

The modern clinical laboratory is called on to do work of extreme complexity. Urinalyses, blood counts, and simple blood chemistry determinations no longer suffice the modern internist. As fast as new discoveries are made in research laboratories, they are seized on for application to medicine. The methods discovered to extract a new ingredient of human secretions in the research laboratory are quickly adapted for determination of that ingredient, in samples not larger than 10 cc. The substance to be determined is usually present in amounts which required for whole number reports the expression "milligrams per 100 cc." Labile materials, which undergo decomposition with slight change of temperature, pH, or other conditions, are worked with constantly. As a result of the increasing complexity, there are beginning to appear in original papers warnings against entrusting such work to ill-trained persons.[6]

THE CLINICAL CHEMIST DOES NOT DIAGNOSE DISEASE

Like the chemist in any other field, the clinical chemist must understand more than the mere technical details of his work. He must know intimately the literature of his specialty in application as well as in performance. He must be able to explain the technic and the scientific significance of his results to those who use his services; and he must thoroughly appreciate the exact nature of his own services so as not to overstep the limits of propriety.

Just as the chemist in industry is frequently called upon for reports concerning the chemical aspects of a project, including its business possibilities, so the clinical chemist is expected to understand the applications of his work and to make recommendations of suitable laboratory procedures for determining facts which may aid the physician in arriving at his diagnosis. In both instances the chemist's reports and recommendations are important factors, but are not binding upon the recipients thereof. Because of banking, political, or other factors, the business executive may set aside the industrial chemist's report. Similarly, no matter how striking a clinical laboratory report may be, the physician does not accept it as a diagnosis, but in-

[4] FOLIN, O., "Laboratory manual of biologic chemistry," 5th ed., D. Appleton-Century Co., New York City, **1934**; "Laws governing the chemical composition of urine," *American Journal Physiology*, **13**, 66 (1905).

[5] "Quantitative clinical chemistry," PETERS, J. P. AND D. D. VAN SLYKE, The Williams & Wilkins Co., Baltimore, Maryland, **1931–1932.**

[6] "Although the preliminary test and most of the quantitative procedure may be carried out by a person with little chemical training, we strongly urge that persons using the method have the assistance of a local chemist . . . " HARGER, R. N., "A rapid chemical test for intoxication, employing breath," *J. Am. Med Assoc.*, **110**, 784 (March 12, 1938).

terprets it in the light of his understanding of the case.[7,8]

For example, the presence of sugar in urine does not necessarily signify diabetes, nor does a positive Wassermann test always spell syphilis.

SOURCES OF CONFUSION

It sometimes happens that the chemist in industry decides that both the technical and the business aspects of his judgment are correct, and proceeds to act on that basis. When he does so, he assumes the capacity of the business executive. There is nothing to prevent him from experimenting with the hazards of business.

The situation is quite different, however, in the case of the clinical chemist who attempts to determine the presence or absence of disease by interpretation of his laboratory findings. If he does so, he assumes the function of the medical diagnostician.

Lack of appreciation of this distinction between laboratory science and the practice of medicine is sometimes found in laboratory circles. Thus an article which appeared in *The Catalyst*[9] under the title of "Technicians" stated, "The efficient technician can interpret the results of his findings and thus present to his doctor an intelligent laboratory diagnosis regarding the ailment of the patient." The Philadelphia Section of the American Chemical Society promptly repudiated this article.[10]

Just as confusion exists in the minds of some clinical laboratory workers as to precisely what they are doing, so there has grown up considerable confusion in the minds of some medical men specializing in laboratory work. Some clinical laboratory workers have erroneously assumed that by performing laboratory tests they diagnose disease. Some physicians have erroneously assumed that because the facts established in the laboratory enter into the welfare of their patients, they are the only ones entitled to conduct a clinical laboratory. Physicians who had become accustomed to operating small laboratories with their offices, naturally looked upon them as an essential part of their practice. It was easy for these physicians to forget that practically every procedure carried out in the clinical laboratory originated in the mind of a research worker in pure science; that year by year clinical laboratory tests become increasingly complex and beyond the skill or capacity of technicians or even of physicians not specially trained in the fields of chemistry and bacteriology; and that the caliber of the work done by laboratory assistants under the general supervision of some one having little fundamental training in analytical chemistry, could not, in the long run, be otherwise than inferior to that of a highly trained analyst.

CLINICAL CHEMISTRY CALLED INTO QUESTION

Having thus forgotten the essential difference between the determinative function of a laboratory test and the medical or interpretive rôle which it plays when integrated with other clinical factors, a determined small group of physicians, specializing in laboratory work, began to question clinical chemistry as a whole. If the small laboratory, which was a part of the physician's office, was essential to his practice, they reasoned, were not clinical chemists working in their own laboratories actually practicing medicine? This illogical conclusion, fantastic as it may seem, was fostered with strong journalistic support. Both by pressure on physicians[11] and by other means,[12] attempt has been made to deprive the public of the trained skill of the chemist and the chemist of his constitutional right to practice his profession. Fortunately, the vast majority of sensible medical men has given little credence to a contention so transparently disingenuous.

Speaking of chemists and other non-medical scientists in the clinical laboratory, whose status was questioned by a governmental board (see footnote 12), the Board of Directors of the Philadelphia County Medical Society, reporting its conclusions to its parent body, the Pennsylvania Medical Association, after thorough investigation, stated unequivocally:[13] "It is silly to infer that these men are practicing medicine." In so saying the Board not only was obeying the dicta of common sense and public interest, but was taking the advice of the Bureau of Legal Medicine and Legislation of the American Medical Association.[14]

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[7] " . . . . it must be clearly recognized that the methods or 'tests' of the laboratory are in *no sense to be taken as signifying tests for the presence or absence of disease.*"—(Author's emphasis). KILDUFFE, R. A., "Clinical urinalysis and its interpretation," F. A. Davis Co., Philadelphia, Pennsylvania, **1937.**

[8] "These examinations are necessary in many instances as supplementary tools in determining diagnosis and in providing information not otherwise procurable. But the laboratory findings are valuable only in so far as they are correlated with the medical problem of a given patient."—"An introduction to Medical Economics" (An Outline Prepared by the Bureau of Medical Economics, of the American Medical Association, Chicago, Revised in 1935), pp. 27–28.

[9] KEFFORD, F. L., "Technicians," *The Catalyst*, **23**, 102 (May, 1938).

[10] Resolution, Philadelphia Section, A. C. S.; *The Catalyst*, **23**, 124 (July, 1938).

[11] "In order to secure the best analyses for the benefit of their patients, *as well as to conserve the interest of the medical profession*, physicians should refuse to have their work done in laboratories conducted under the direction of non-medical persons." (Emphasis supplied.) *J. Am. Med. Assoc.*, **95**, 980 (Mar. 24, 1928).

[12] "Clinical laboratories do enter into the welfare of patients, inasmuch as reports from them are requested and secured by physicians only because of their aid in the diagnosis and treatment of cases. It is obvious, therefore, that all such reports should be made by licensed physicians who may be legally responsible for them." I. D. Metzger, M.D., Chairman of Pennsylvania Board of Medical Education and Licensure to A. J. Nydick, Esq., letter of November 11, 1937. Dr. Metzger's contention received formal refutation on behalf of the American Chemical Society in a brief submitted by Mr. Nydick to the Attorney-General of Pennsylvania, July 23, 1938, *Ind. Eng. Chem., News Edition*, **16**, 481 (Sept. 10, 1938).

[13] *Pennsylvania Med. J.*, **41**, 738 (May, 1938).

[14] "The analysis, by chemical or physical means, of specimens submitted for that purpose, followed by a report showing the results of the analysis and nothing more, can hardly be classed as the practice of medicine." (P. 2, col. 2.) William C. Woodward, M.D., LL.B., Director, Bureau of Legal Medicine and Legislation, American Medical Association. Reprint—Proceedings of the Annual Congress on Medical Education, Hospitals and Licensure, p. 35. Chicago, February 18 and 19, 1935.

A. C. S.—A. M. A.—A. A. P. B. JOINT RECOMMENDATIONS

As far back as 1923, the American Chemical Society saw the need of protecting the public from inferior clinical laboratory work. A similar view was expressed at the same time by the House of Delegates of the American Medical Association. As a result, representatives of these organizations met jointly with a delegation from the American Association of Pathologists and Bacteriologists in 1924, and formulated the following recommendations:[15,16]

1. That it should be illegal for any person not licensed by law so to do, to assume the responsibility of making the diagnosis or of deciding on the progress or source of disease on the basis of any results of a chemical, pathologic, serologic, bacteriologic, radiologic, or microscopic observation or other laboratory examinations undertaken; and that where laws do not now restrict diagnosis or the clinical interpretation of laboratory examinations to licensed classes of medical practitioners, laws should be enacted to effect that end.
2. That any law providing for the licensing of professional workers in laboratories devoted to ascertaining the presence, progress, or source of disease should provide for the examination of members of each profession by competent authorities belonging to the same profession.
3. That as long as an organization or individual engaged in examinations to ascertain the presence, source, or progress of disease refrains from all diagnostic and prognostic interpretation of the results of such laboratory tests as provided for in paragraph 1, any effort to force such organization or individual to place itself under the direction of a representative of any other profession is to be deprecated.
4. That the American Chemical Society, the American Medical Association, and the American Association of Pathologists and Bacteriologists should coöperate to establish the principles enumerated in the foregoing resolution whenever legislation in this field may be proposed, and that the coöperation of other national bodies should be solicited.
5. That clinical laboratories be standardized in accordance with the principles laid down in the preceding paragraphs, and legislation should be enacted to insure competent personnel and suitable equipment.

These recommendations protect the safety and welfare of the public and establish a base for the proper mutual relationship of medical men, chemists, and bacteriologists. They have been scrupulously observed by the American Chemical Society. It is to be hoped that the American Medical Association, as a great organization sensible of its responsibility to the public, will call to account those few of its members who have forgotten that agreement, no matter how highly placed they may be.

The euphoric misconceptions of the small, but apparently powerful minority of laboratory physicians, which has sought to stake out clinical laboratory activities as its private domain, contrary to the 1924 agreement have naturally caused concern to chemists.[17] To the extent that such misguided efforts have succeeded, the interests of the public and of the medical profession as a whole have been sacrificed; the former by depriving it of the skill of competent scientists, the latter by substituting for true specialists in the analytical sciences semiskilled technicians or professional men whose training in analytical fundamentals is to a large extent only incidental to a broad training in other fields.

THE FUTURE OF THE CLINICAL CHEMIST

The place of the clinical chemist in society is secured not only by his specialized skill and scientific background but by the opinions of those who are best qualified to judge the value of his services, namely, those who practice the healing arts. It was the great Osler who expressed most clearly the need of the practicing physician, "How helpful it would be if clinicians had always at hand skilled physiologists, pathologists and chemists to apply their most advanced technique to clinical problems, and not the technique alone, but the biological and chemical principles upon which medicine as an exact natural science is founded."[18]

Folin's epoch-making researches into the composition of the blood and the urine, whose publication began shortly afterward, would appear almost as a direct response to Osler's plea. Even today, when acquisitive ideas tending to challenge the chemist's rightful status are being artfully publicized under the guise of "eliminating laymen from medical work" we do not lack for clear thinkers among pathologists: " . . . it is becoming increasingly clear that the serious student of disease, whether working primarily in the pathological laboratory or in the clinic, must be equipped to study or direct the study of his problem by physical, chemical, mathematical, and experimental methods, as well as by the older methods of anatomy or bedside study, as the case may be. This should not be regarded as encroaching on the fields of the biophysicist or biochemist any more than is their activity an encroachment when they study pathological as well as normal conditions. Helpful partnerships should often be resorted to; but even without them the field is large enough for both."[19]

The future of the clinical chemist depends to a large extent on practical recognition by medical men and hospital executives of his natural position as leader in factual investigation in the laboratory, in the spirit of the 1924 agreement. Experience has shown that among medical graduates only a few have that genuine interest in the coldly objective work of the laboratory,

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[15] *J. Am. Chem. Soc.*, **46**, 81–2 (July, 1924).

[16] *J. Am. Med. Assoc.*, **86**, 1065 (April 3, 1926).

[17] Resolution passed by Philadelphia Section, A. C. S., May 16, 1938: "Whereas, the rightful status of chemists, who are analysts, teachers and research workers in fields allied to medicine, has been called into question by reports and editorials in the Journal of the American Medical Association and publications of constituent organizations thereof, Be it Resolved, That the Philadelphia Section of the American Chemical Society go on record as expressing its deprecation of these unfriendly moves against chemists and as reaffirming its belief that the rightful status of clinical chemistry was properly established in 1924 by the joint agreement of the American Chemical Society, the American Medical Association and the American Society of Pathologists and Bacteriologists." *The Catalyst*, **23**, 119 (July, 1938).

[18] Introductory Note by Sir William Osler to KREHL, L., "Principles of clinical pathology," J. B. Lippincott Co., Philadelphia, Pennsylvania, **1905.**

[19] KRUMBHAAR, E. B., "Pathology," Paul B. Hoeber Co., New York City, **1937.**

which is the inherent attitude of the chemist. While medicine will always remain to a large extent an art,[20] the subjective attitude has no place in the laboratory. Objectiveness is a *sine qua non* for a laboratory director. By the very nature of medicine, only exceptional medical men became genuinely qualified for direction of the technical phases of laboratory science.[21] The medicine of the future will be best served by the coöperation of chemist and pathologist recommended by Sir William Osler thirty years ago and Dr. Krumbhaar today.

IS CHEMISTRY A PROFESSION?

The field of clinical chemistry is one of especial responsibility to the public. A clinical chemist who practices without a complete understanding of his responsibility does harm not only to public welfare, but to the profession of chemistry as a whole. In this very necessity for self-examination by chemists specializing in this field there lies the seed for self-understanding and improvement of the profession of chemistry as a whole.

Those who question the status of clinical chemistry do not stop at the clinical chemist *per se*. Chemists who are teachers and research workers in fields allied to medicine have been specifically mentioned as "entering into the welfare of the patient" and thus usurping functions which are claimed to belong solely to licensed physicians. Doubts have been expressed as to whether chemistry is a profession of the same class of responsibility to the public as medicine, law, theology, and so forth.

It would seem unnecessary to dignify this challenge with a reply, which indeed, has already been given by the United States Supreme Court.[22] The A. C. S. By-laws speak for themselves. Membership is open only "to any reputable person who has had adequate collegiate training in chemistry or chemical engineering, or its equivalent, and who had been actively engaged in some form of chemical work or graduate study for at least three years, except that only two years of experience will be required for graduates from institutions, the adequacy of whose course had been accredited by the Society."[23]

Educationally, legally, and from the viewpoint of duty and responsibility to the public, chemistry is on a par with other professions and gives freely of its learning to all of them. It suffers from lack of understanding by the public, a term which here includes members of other professions. It suffers also from the activities of unqualified persons who call themselves "chemists." It can benefit, however, from the challenge to its standing by learning better to understand itself.

With self-understanding, proper and efficient presentation to the public of its aims and accomplishments, and active coöperation with other professions in unselfish service of the public, the chemical profession can function increasingly for the benefit of mankind. Without a heightened and watchful guarding of the public interest which lies within its field, it may find itself severely handicapped, to the detriment of general public welfare.[24]

ACKNOWLEDGMENT

Acknowledgment is gratefully made to A. J. Nydick, Esq., for citations furnished and helpful suggestions.

[20] "Even with all the advances made, the almost infinite variability of conditions in disease teaches the wisdom of preserving medicine as an art, even while it is becoming more exact and scientific. No two patients with nephritis (or any other disease) present identical problems or identical reactions. The almost intuitive summing up in diagnosis by a physician feeling his way carefully among a variety of possibilities is based after all on an integration of all his knowledge and experience bearing on the evidence of a given case. This is characteristic of medicine as an art." STIEGLITZ, E. J., "The chemistry of kidney failure" in "Chemistry in medicine," The Chemical Foundation, Inc., New York City, **1938**, p. 541.

[21] In six years of diligent search from 1925 to 1931 the Council on Medical Education and Hospitals of the American Medical Association, found in the United States only one hundred eighty-three physicians qualified to direct laboratories under the strict educational qualifications recommended by the joint committee in 1924. (*J. Am. Med. Assoc.*, **96**, 1794 (1931).)

[22] "Formerly, theology, law, and medicine were specifically known as *the professions;* but as the applications of science and learning are extended to other departments of affairs, other vocations also receive the name. . . . . The chemist who places his knowledge acquired from a study of the science to the use of others as he may be employed by them, and as a vocation for the purpose of his own maintenance, must certainly be regarded as one engaged in the practice of a profession which is generally recognized in this country." U. S. *vs.* Laws; U. S. Supreme Court, 163 U. S. 258, p. 266.

[23] A. C. S. By-laws #19-A. *Ind. Eng. Chem., News Edition*, **16**, 53 (Jan. 20, 1938).

[24] "Not only must chemists take an active interest in the affairs pertaining to society, but they are doubly justified in so doing where proposed action lies in the field in which they have some competence." EDITORIAL, "Under congressional consideration," *Ind. Eng. Chem., News Ed.*, **16**, 129 (March 10, 1938).

A SIMPLE EXPERIMENT IN COAL TAR DISTILLATION

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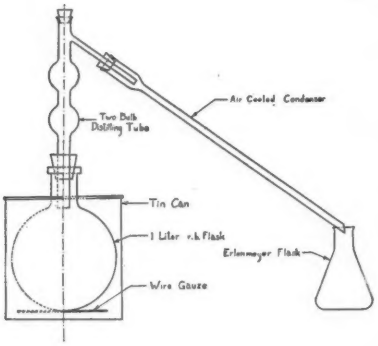
THE author has found that experiments which show commercial processes are, in general, very interesting to beginning students. Many elementary laboratory manuals contain an experiment on the de-

structive distillation of wood. The students enjoy it because it deals with common materials and the pyroligneous acid collected reminds them of patent meat curers. An experiment on the fractional distillation of crude petroleum is often found in organic manuals. Work with coal tar, however, is rarely taken up in any elementary course. The use of coal tar products is so extensive and the nature of the products as compared to the parent coal tar is so astounding that it would seem to be a worth-while addition to an elementary laboratory course. The author, after consulting various commercial analytical texts, has prepared the following



directions based on a section in Allen's "Commercial Organic Analysis."[1] These have been successfully used by about ten different classes. The tar used here was obtained from the local gas plant, but any coal tar may be used.

Place 150 ml. of the tar in a liter round-bottom Pyrex flask fitted with a two-bulb distilling tube and an air-cooled condenser. Cork stoppers are preferable to rubber stoppers. A tin can just a little larger than the flask should be used to promote even heating. Remove the top of the can, and cut a small hole in the middle of the bottom to fit over the neck of the flask. Turn the can upside down over the flask. Provide three containers for the products which will consist of:

(1) (*a*) Ammoniacal liquor from which ammonia and pyridine (C_5H_5N) are obtained commercially and (*b*) light oil from which by fractional distillation benzene (C_6H_6), toluene, ($C_6H_5CH_3$), the xylenes, ($C_6H_4(CH_3)_2$), naphthalene, ($C_{10}H_1$) from which mothballs are made.

(2) Creosote oil which consists of carbolic acid or phenol (C_6H_5OH), the cresols ($C_6H_4(CH_3)OH$) used in lysol, naphthalene ($C_{11}H_2$), and some small amounts of other compounds including those of sulfur.

(3) Anthracene oil which contains mostly anthracene ($C_{14}H_{10}$), phenanthrene ($C_{14}H_{10}$), and carbazole ($C_{12}H_9N$).

(4) Pitch which remains on the flask and consists of coke and unidentifiable tarry materials.

It is unnecessary to use a thermometer, as the character of the distillate is sufficient to indicate the point at which the receiver should be changed.

When all is ready place a small burner under the flask over a wire gauze and heat very slowly at first. Caution is necessary since the water in the tar causes steam distillation, and superheating may cause frothing. The first fraction which is received will consist of a mixture of oil and an aqueous solution, the latter being on the bottom.

(1) *Ammoniacal liquor and light oils.*—During this distillation the vapors should be tested for ammonia by the use of moistened red litmus and by the odor. When this fraction of the distillation is complete, distillation will cease for a while and a peculiar noise called the "rattles" will be heard. Change the receiver at this point.

(2) *Creosote oil.*—Apply more heat gradually until distillation recommences and collect this fraction until another break in the process is noted. Provide a third container.

(3) *Anthracene oil.*—Heat more strongly. The distillate will become crystalline in the condenser and receiver. The solid material is mostly anthracene. Continue heating until no more liquid distills. If extreme care is not exercised here the liter flask may melt or crack during this process.

(4) *Pitch.*—The residue in the flask is pitch. Separate the oil from the ammoniacal liquor, note the volume of each and record. Likewise record the volume of the other fractions and any other pertinent observations. Place each of the fractions in the separate larger containers for the whole class.

Repeated fractionation of these combined portions may be carried out if time permits. The writer has found, however, that the anthracene oil fraction gives the best results, since crystalline anthracene is obtained and may be identified.

[1] DAVIS, W. A. AND S. S. SADTLER, "Allen's commercial organic analysis," Vol. III, pp. 20–9, 4th ed., P. Blakiston's Son and Co., Philadelphia, Pa.

A SYSTEMATIC ORDER *of* PRESENTATION *of* MATERIAL *in* GENERAL CHEMISTRY*

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THE objectives of a college course in general chemistry, it seems to the writer, should determine not only the content of the course but also, to a large extent, the order of presentation of material. Before outlining an order of presentation which seems to the author to be a more logical one than that found in most of our texts it will be appropriate to state what the writer considers to be the chief functions of a first course in general chemistry. There is quite a prevalent opinion among educators that there should be one course in chemistry, and that a rather technical one, for students definitely intending to take advanced courses in the subject, but an entirely different one for those taking only one course in chemistry or in any science. It is the belief of the writer that one and the same course can best serve both groups of students. The author is willing to go one step farther and say that this makes of the course a non-descriptive, or a theoretical one, in which the stress is put upon the theoretical principles of the subject. These statements are justified by the belief that the major thing which a student has a right to get from a course in chemistry is some development of his reasoning ability. This is not, of course, the sole objective, but the writer wishes to emphasize it by restating that she believes that the development of the student's reasoning ability should be the main objective of a first course in chemistry or physics. If courses in physical science do not give the student some kind of training and mental development other than that he gets from literary subjects, or even from a first course in a biological science, he might just as well read a few popular books on chemistry or physics and pick up informational facts from papers and magazine articles and not take the course in chemistry. As the writer sees it, the student takes a course in chemistry, or should take it, for something more than factual knowledge. And this is just as true for the student who expects to take no more chemistry or other science as it is for the student who expects to take more work in the subject, and, conversely, it is just as true for the student who expects to take advanced work in the field as it is for the person who is taking the course only for its value in a general, liberal arts education. Even if the reader cannot agree with this point of view it makes somewhat clear the author's position in saying that one and the same first course in chemistry can well serve both groups of students found wishing to take some course in chemistry or in a physical science.

Acting in accord with the above view, a number of purposes have been kept in mind in working out the material to be included in the course and a logical order of presentation of the subjects selected. The course herein outlined has for its objectives the following, or it attempts to give the student:

(1) A comprehensive view of one science which will give him some appreciation of all science, some appreciation of the beauty of natural law, some understanding of the spirit of science and the scientific method and the high cost in human effort of our knowledge of natural phenomena.
(2) Some development of the power of observation, the ability to reason logically, and to draw rational conclusions from a set of data.
(3) A definite correlation between chemistry and other sciences and between chemistry as a representative of natural science and other branches of knowledge.
(4) The subservience of detailed descriptive matter and everything else in the course to these main objectives.

In an effort to approach the above ideals the material of the course has been organized to make one subject lead as logically as possible to the next one and to make the facts learned in a discussion of experimental work "force" the chemist into a possible explanation of them, or into the formulation of theories about the nature of matter. This arrangement also gives the best opportunity to show the student how theories must be carefully examined by further experimentation and must be modified, or even discarded, if necessary, to meet the demands of new facts as discovered. A real effort is made to get the student to look backward over the branch of science he is studying to something of an understanding of the slow and faltering progression from facts to theory, then from a study and testing of theory to the discovery of new facts which in turn will be followed by subsequent theory, and this in its

* Presented before the Division of Chemical Education at the ninety-third meeting of the A. C. S., Chapel Hill, N. C., April 13, 1937.

turn by new facts, and so on and on until the student has caught something of the spirit and of the method of science which ever leads onward to a better understanding of natural phenomena and a closer approach to the goal of all science.

In the interest of the above objectives the historical order of presentation of material is used as much as possible. The history of the development of a theoretical principle contributes to an understanding of the present status of the principle, emphasizes the fact that the subject is a dynamic one, and, indirectly, shows the student that most of our knowledge is the outgrowth of slow processes of human effort rather than of revelatory inspiration. Also, in the interest of this latter idea names of scientists are as definitely linked as possible with all of the material of the course, so that the great figures in the history of chemistry become personalities who actually live and move before the students and inspire them. Through the historical method the students come more easily to an appreciation of the fact that human opinion is not the ultimate court of appeal of the scientist than they do by any other method the writer has tried.

The course being presented does not presuppose any previous training in any science. No book is used as a text, but the students purchase one or more texts which they use in connection with a number of standard texts available in the laboratory and library. A laboratory manual with the above objectives in view which embodies some appreciable departures from the classical manual has been worked out by the author for this course.* In general, the students are asked to recite on a subject only after they have heard a discussion of the material in the class room and have considered it themselves in a laboratory study period.

The work of the course is started with general remarks regarding the nature of natural sciences, the twofold purpose of science, the similarity of a natural science to other branches of knowledge, and its differences from them. This latter point gives some opportunity to get the idea over to the student that in chemistry one subject leads more definitely and more logically to the next one than is possible in most of the other subjects he is taking. It also gives the teacher an opportunity early in the course to give the student the proper conception of the laboratory work and to help him see it as an important and integral part of the whole which completely does away with the feeling that he is taking two courses in chemistry. If the student can see the course as a sort of mosaic and see that each piece must be in its place in order to make the whole perfect his interest in all of the work of the course is rather easily held. These discussions are followed by a brief one on the position of chemistry among the other sciences.

It is not difficult after these introductory lectures to point out the necessity of the choice of very accurate terms in the study of a science, or the importance of acquiring a scientific vocabulary. A discussion of the definitions and meaning of thirty-five or forty scientific terms as an immediate working vocabulary is considered at this point. It is fairly obvious that this can include much of the work found in the first few chapters of most texts, but the discussion is given meaning and becomes something more than the detached materials of chapters one and two or of two and three of some textbook in chemistry. These definitions, together with the lecture experiments accompanying them, give an excellent opportunity to make a beginning at the main objectives of the course. A brief survey of the periods into which the history of chemistry may be divided is included in this connection. This gives the student not only some conception of the recent position of the material of the course in the history of the subject and the history of mankind, but it also gives him some appreciation of the relation of the science of a period to the civil history, the art, and the literature of the period.

Next, in the belief that Pat was right when he said that a subject would be easier to learn if one could know something about it before starting to learn it, a brief and elementary outline of the modern conception of the atom is given. This, an understanding of the ultimate constitution of matter, is presented as one of the chief goals of the course and of all the study of theoretical chemistry. In presenting this as one of the chief objectives of the course the students are told that most of the material given is arranged to lead as logically as possible by the scientific method over the discoveries of the past to those demanding the present conception of matter. In this bird's eye view of the atom the elements are spoken of entirely by number and the students are told that the number of the atom represents the number of electrons outside the nucleus. The stable structures and the tendency of the atom to revert to these stable forms are pointed out. When told that the tendency to gain or lose electrons in the valence level is responsible for the activity of one element toward another it is easy for the students to understand that atoms which tend to lose electrons would combine with those that tend to gain and *vice versa*. After working out the arrangement of planetary electrons for atoms of atomic number lower than twenty-five the student can readily predict whether any two elements would have a tendency to combine with each other and he writes such formulas as 11,17, or $20(17)_2$ at this point. The class derives keen pleasure from this work, sees some real reason back of the subjects included in the course, and proceeds with an appreciable enthusiasm to the less spectacular work of the course and that which is generally considered less interesting. One can readily see that this discussion makes the subject of valence and the writing of formulas and equations seem reasonable and easy and puts them entirely upon a reasoning basis. It may be stated somewhat parenthetically that even this brief discussion of the modern theory of the structure of the atom

* For discussion of the laboratory manual *cf.* FILLINGER, H. H., "Some departures from classical laboratory methods in general chemistry," J. CHEM. EDUC., **13**, 487–90 (Oct., 1936).

presents an opportunity early in the course to give the student some appreciation of the function of various forms of energy in bringing about reactions and also some conception of the profoundness of a chemical change.

After the foregoing introductory material there is no forcing of the point to begin the course proper with a rediscovery of the three most fundamental laws of chemistry which put the subject on a scientific basis. Since the students have been told that the material of the course has been arranged so that they may "stand by" and "work with" the chemists of the past and watch them discover the great principles of the science they are studying, a consideration of these laws seems to be a logical subject for an early lecture. The author has never tried as successful a method as this for keeping up the interest in the so-called duller and more technical work of the course and has never found any method equal to it for leading the student to some appreciation of the methods of the scientist. In order to "rediscover" these three fundamental laws it is necessary to work with matter in its least tangible form, the gaseous state, and to study some of the properties of gases and the laws governing their behavior. This obviously leads to a "discovery" of the gas laws. The students see the study of the gas laws and the handling of gases as a necessary part of the course and one that must be considered at the beginning of the work. These laws become something more than a somewhat dry and detached subject stuck into the course to fulfil the fancy of the author of a text or the teacher of a course. A rather detailed discussion of Lavoisier's critical study of combustion is considered as leading to the establishment of the Law of Conservation of Matter (or, perhaps, the present Law of Conservation of Mass-Energy) and marking the beginning of the quantitative method for which the modern period in the history of chemistry stands. Since the laws of Definite Composition and Multiple Proportion can best be "rediscovered" through a consideration of the quantitative analysis of gases a brief study of oxygen and hydrogen, without real emphasis on the elements themselves, is taken up. The author does not believe in introducing a detailed study of any element, particularly the non-metals, into the course until after a thorough discussion of the Periodic Table and the modern conception of the atom have been given in detail and postpones all further study of the elements to that point. In connection with this study which leads to the Laws of Multiple Proportion and Definite Composition formulas for gaseous compounds, which represent primarily 22.4 liters of a compound under standard conditions, are worked out and densities of gases and percentage composition of compounds are worked out from formulas.

After a discussion of the above laws the class is quite ready for some explanation, for the postulation of some theory, which will explain why matter behaves in accord with the principles just considered. The Kinetic Molecular Theory and Dalton's Atomic Theory are presented as the best explanation for the facts just considered and for the three fundamental laws of chemistry. In this connection it is easy to mention the two tests to which a theory must be subjected and to state that discoveries of the latter part of the nineteenth century and the early years of the twentieth century have demanded some changes in the Atomic Theory and that further modifications will be made if the facts of the future require them. This arouses quite an interest on the part of the better students in the future subject matter of the course and helps them catch something of the scientific method.

A discussion of the two theories just considered presents the next subjects which can be logically taken up at this point. A belief in the existence of molecules and atoms certainly leads to an investigation of their properties. Students can see why weights, or relative weights, of these minute units of matter and the number and kind of atoms in the molecules of compounds became interesting and important subjects which engaged a goodly portion of the attention of the chemists of the early years of the nineteenth century. Statements of Avogadro's Theory and its meaning and significance lead to a discussion of a density method of determining molecular weights of gases and volatile compounds. Approached in this fashion the work on molecular weights and the determination of the molecular weight of a gas in the laboratory become not only a necessary part of the course instead of an appendage to it in order to please some person or to make the work difficult and uninteresting, but also a subject of considerable interest. A brief outline of the early work on atomic weight determinations which begins with Dalton's work based on false premises is given. This survey brings the discussion to a situation in the middle of the century when there was no unanimity of opinion on a method of determining atomic weights and the class finds that there are about as many atomic weights for an element as there are eminent chemists interested in the subject. Even the freshman student can see the seriousness of this situation and the necessity for the famous meeting of one hundred, or more, chemists at Karlsruhe in 1860 to discuss the important subject of atomic weights. A brief presentation of the convention leads to a statement regarding a paper on atomic weight determinations which Cannizzaro distributed among some of the delegates. The drama of this meeting and its epoch-making paper which caused the "scales" to fall from Lothar Meyer's eyes and slowly convinced the remainder of the scientific world of its truth arouse a wholesome curiosity regarding the contents of the paper. After this bit of the history of the subject the students proceed with considerable interest and enthusiasm to a detailed study of atomic weight determinations. Cannizzaro's reasoning is given in some detail as a beautiful example of logical thinking and the method by which a scientist works. The better students see something of the beauty of the logic and come to believe that the method

is correct unless the premise is false. They seem to find it easier to understand and remember this method of determining approximate atomic weights than when it is taken up at no particular point at all. It also seems to stimulate some interest in the Dulong and Petit method of determining approximate atomic weights, in a consideration of equivalent weights, and in the relation between equivalent weights and exact atomic weights, and so forth.

As water plays such an important rôle in chemical reactions a rather full discussion of the properties of water and of solutions is next introduced. A study of the effect of solutes on the vapor pressure of water and the discovery of Raoult's Law lead very naturally to boiling-point and freezing-point methods of determining molecular weights of non-volatile compounds and thus complete the discussion on molecular weights.

Next, a systematic study of writing formulas and equations, the classification of inorganic compounds, and the nomenclature of acids and bases and salts is taken up. This includes a thorough study of valence and a reference to the first discussion of the structure of the atom. Much drill work is given at this point and is continued in season and out of season until the author is sure that all but the poorest members of the class are quite proficient in the work. In this drill students work with formulas which they have never seen before, write formulas of compounds they have never heard of, name these compounds and write equations for metathesis reactions between them in water solution. This puts the material upon a reasoning basis and makes memory work at this point practically impossible. A discussion of the four classes of chemical reactions, methods of preparing salts, factors affecting the choice of methods of preparing them, either on a small scale or a commercial scale, are natural parts of the work on equations and furnish more opportunity for practice in writing equations. In the laboratory as well as in the written work outside of the laboratory, students choose their own materials for the successful preparation of many soluble and insoluble salts and either separate their products and obtain them in solid form or tell how they could be separated. A discussion of the Electromotive Series of Metals and of Non-metals very easily becomes an integral part of a discussion on methods of preparing salts and is included here.

In order to introduce the Theory of Ionization the fact is recalled that in the study of solutions it was noted that only certain types of compounds seemed to obey Raoult's Law and that other compounds showed abnormal effects. The facts explained by Arrhenius' Theory, or rather the facts demanding it, are presented in some detail. The class has, by this time, become accustomed to the demand for an explanation which a set of facts about natural phenomena makes so they are eager for some explanation of the most unusual and interesting experimental facts just considered. Before presenting the Arrhenius Theory of Ionization the author asks the class to propose a theory which will explain some of the facts in the case. No student who has had any previous work in chemistry is permitted to make a proposal. Fairly easily the writer gets one or two assumptions tending to explain the abnormal effects of electrolytes on vapor pressure. As soon as these are forthcoming a careful examination of them is begun to see if they do explain adequately the phenomena under consideration. The temporary theory rather soon proves inadequate. With help, largely in the form of questions, the class begins to modify the theory in an effort to try to make it meet a large number of the facts in the case. This formulation of assumptions and the modifications of them are allowed to proceed as long as they seem to prove profitable to the class before they are stopped and the Arrhenius theory is presented. This approach gives the students a real personal interest in, and a feeling for, the theory and the better students not only become positively excited over its assumptions, but also they get some definite idea of the birth and development of a theory in the hands of an advanced student of chemistry. The author feels that some of the fine things of the course are accomplished at this point.

The students are next reminded that the theory of Arrhenius must be subjected to the same kind of rigorous examination to which their theory was subjected and that it must continue down through the years to be submitted to the test of new facts as they are discovered. It is mentioned that Arrhenius' Theory has stood both of these tests remarkably well and that only comparatively slight modifications have had to be made in recent years. A brief discussion of the Debye-Hückel Theory of one hundred per cent. ionization for strong electrolytes is given. In this connection the term, "degree of effective ionization" is offered as a substitute for "degree of ionization." Some work on crystal structure and the possible ionization in the solid state and some discussion of hydration of ions, including hydrogen ion, are given at this point. Also, in this connection some work on structural formulas, a more critical study of valence, and the electrical nature of valence are appropriate. Some suggestions as to how water, heat, and light may bring about ionization are given. Some remarks on polar and non-polar valence and the latter as a possible explanation for the principal ionization of electrolytes are included. The subject is presented as an unfinished problem and one giving opportunity for further study and research and again the students are reminded of the difference between fact and theory and the real thrill and pleasure in the study of a subject, the knowledge of which is incomplete.

The Theory of Ionization has really introduced the subject of reversible reactions, so a slight reference to the incomplete discussion of the meaning of one of Arrhenius' assumptions is quite enough "excuse" for taking up a careful study of reversible reactions, methods of testing for very slight reversibility of seemingly complete reactions, and the whole subject of chemical and physical equilibrium. The subject of chemical

equilibrium, the principle of Le Chatelier, methods of shifting equilibrium, suppression of ionization, and hydrolysis are considered as thoroughly as possible. The students have laboratory work in this connection which they partially plan themselves, or rather, they select some of their chemicals and the methods to be used. Successful laboratory work on this subject insures an understanding of the principles involved and demands some clear thinking on the part of the student. The laboratory work which the better students find particularly stimulating in connection with equilibrium, including work on the Theory of Precipitation and the Theory of Dissolving Insoluble Compounds, is so arranged that it cannot be done well by students who do not understand the simple principles and it cannot be done at all without some thinking on the part of the person performing the experiments. Students get the material on a reasoning basis and hand in laboratory reports which show this, or they hand in very poor reports, or else they get too much help from an instructor. The latter knows in which of these classes each student belongs.

After the above discussions the students are told that they should have a sufficient understanding of fundamental principles to begin a study of the ninety or ninety-two known elements. However, in order that this may be done intelligently and with the minimum amount of memory work and the maximum of application of all of the previous material of the course the elements must be classified and the study systematized. An historical discussion of proposed classifications beginning with Döbereiner's Triads and ending with Lothar Meyer's and Mendeléeff's work is given. A recollection of the interest in atomic weights during the first half of the nineteenth century culminating in the convention at Karlsruhe and the attendance of the latter by Lothar Meyer and Mendeléeff give plausible reasons for their "juggling" with atomic weights in the belief that a classification of the elements might be effected upon that basis. The students can certainly justify Mendeléeff's explanation of the discrepancy of placing tellurium before iodine in the Periodic Table when they recall that he made it within ten years after the convention at Karlsruhe. Some points about the Periodic Table as a convenient reference table have been given much earlier in the course, but the subject is treated in detail at this point. There is a laboratory experiment on the study of the Table and enough drill work is given to insure an increasing use of it throughout the remainder of the course. The Periodic Table is directly made the basis for all of the remainder of the work of the course.

During the above discussion the students make the usual study of Family A, Group I, as a representative family illustrating the points brought out in the Periodic Table. There is scarcely any class discussion on these elements as individual elements but there is laboratory work on them and the students are held responsible for the points usually taken up in a systematic study of the elements. The discovery of rubidium and cesium is taken up in class as a means of introducing the spectroscope and spectrum analysis. An elementary discussion of radiant energy, the forms in which it exhibits itself, and the methods of detecting radiant energy of different wave-lengths is given. Pictures of spectra and actual bright line spectra of several elements are shown so that the students get some fairly definite conception of what is meant by the spectrum of an element. A brief consideration of the study of X-ray spectra of elements brings the discussion to Moseley's work and the present-day interpretation of Mendeléeff's discrepancy in the Periodic Table and the other discrepancies brought about by discoveries since Mendeléeff's work. Considerable response is obtained from the students and an intelligent interest in the real meaning of the atomic number of an element is aroused.

In an effort to bring the class to some understanding of the meaning of the atomic number of an element and the experimental basis for the statement of its meaning as given in the first bird's eye view of the structure of the atom, a discussion of the nature of electricity must be considered. This study includes a very brief survey of the outstanding work since Volta, a discussion of the passage of a current of electricity through solid conductors in the light of Rutherford's conception of the atom at the close of the nineteenth century, its passage through solutions of electrolytes, and, finally, through gases. Some discussion of the generation of a current of electricity by a chemical reaction of the oxidation-reduction type and of the effect of gas pressure on the passage of a current through gases is given. The work of Crookes and Roentgen and the properties of cathode rays and something of the work of Perrin and others in establishing the nature of the rays, together with appropriate lecture experiments, and an elementary discussion of Millikan's oil drop experiment form a part of the background for a conception of matter as electrical in nature.

During the above discussion the students have been making a systematic study of Family A, Group II of the Periodic Table. A study of radium as a member of this family is taken up in class. It is not difficult for even the poorer students to see that a discovery of radium and radioactivity are a culmination of many discoveries which demand a new interpretation of the atom. By using this approach, which may be called an historical one, the students see that a new conception of matter and a reinterpretation of Dalton's atom are forced upon the chemist. Furthermore, they see that much of the theoretical work of the nineteenth century was leading to a new interpretation of the atom, and they get a perspective and see more of how one generation builds upon the knowledge of another and the part that a small piece of creative work can play in the whole than by any other method used by the author. A composite of the Lewis-Langmuir-Bohr Theories of the structure of the atom is given as a not wholly adequate, or as an incomplete, conception of the atom. It is also pointed out that this theory, recent

though it is, has already been extended by still newer concepts including the wave mechanics theory and that there is much need for further research upon the subject.

After a careful, though elementary discussion of the atom, the students do some very nice work predicting the relative stability of compounds, the ease or difficulty of oxidizing or reducing them, and the oxidizing or reducing properties of the compounds, and so forth. The tendency of an atom to revert to a stable structure, one of its extreme valences, is given as a working hypothesis. This is used in making predictions regarding the stability of compounds, or the ease of oxidizing or reducing them. At this point the students are able to examine the formulas of any compounds of which they can be expected to work out the valences or valence numbers of the elements and predict something of the relative stability of the compound and state whether an oxidizing agent or a reducing agent would be needed in an attempt to prepare a certain free element from the compound. The student can also work out in a similar fashion whether an oxidizing or a reducing agent will have to be used in order to prepare a certain compound from an element. Even the average student in the class can do good work at this point. This is work, too, that cannot be done on a memory basis. The students are given as much drill as possible of the type of examining formulas of compounds as, for instance, those of arsenious acid, arsine, and arsenic acid, and stating whether an oxidizing or a reducing agent will be needed to prepare free arsenic from each compound together with the reason upon which they base their conclusion. Compounds with which the students are unfamiliar are selected somewhat at random until the best members of the class become very proficient in the work before a detailed study of any of the non-metals, except oxygen, is taken up and also before many of the metals have been considered. It is only at this time that the author believes in beginning a detailed study of the elements. Earlier the student is unable to put such work as the preparation of non-metals on a reasoning basis.

If the study of the elements comes after a careful consideration of the theoretical principles of the course and proceeds logically according to the arrangement in the Periodic Table the work can be put very largely upon a reasoning basis and becomes a valuable study which gives the student the maximum mental development. If the metals are taken up beginning with Family A, Group I, and the study proceeds through Families A, in Groups II and III to those of the first Family in Group VIII, and then to Families B of the first three groups and to other elements of Group VIII the study very nearly follows the order in the Electromotive Series of Metals. The conception of the atom with which the students are fairly familiar by this time shows them clearly why reducing agents are needed in the metallurgy of these elements, and they do not have to memorize this fact as many students in a descriptive course still have to do. The students can also see why the most powerful of all reducing agents, the electric current, is needed in the preparation of the alkalies and that as subsequent families are studied and the metals fall lower and lower in the Electromotive Series milder reagents can be used and the application of less heat energy is necessary until a point is reached where the metals occur free in nature and their metallurgy involves only physical processes. The study of the non-metals follows a similar order starting with Family B of Group VII and moving in toward the center of the Periodic Table. This arrangement somewhat follows the order in an electromotive series of non-metals. The amphoteric elements come in for the last treatment. In making the Periodic Table and the modern conception of the atom the basis for the work on the study of the elements, the chance for memory work is reduced to the minimum and the necessity for logical reasoning is apparent. The study of the non-metals, and particularly that of the acids of Groups V, VI, and VII, becomes a very different thing than if taken up somewhat at random as it would be if the order in many of our texts were followed. This study of the acids can well be made into a study of the hydroxides as suggested by P. M. Glasoe* a little more than a year ago. The beauty of what the author has chosen, for want of a better term, to call a systematic order of presentation of material, bears some of its best fruits in connection with the study of the non-metals and the work on oxidation and reduction. Subject matter which can be very difficult and seem somewhat like a senseless mass of memory work becomes material which can be largely reasoned out by the beginner. The student can also see that much of the trial and error process can be removed from his experimental work as well as from that of the research chemist. The students of the course here discussed have a laboratory manual designed to help accomplish the objectives of the course. They plan some of their own work, often select their own reagents, or a part of them; they decide whether mild or vigorous reagents are needed, and predict something of the amount of energy required for the reaction. But the laboratory manual which proposes to help do the things that the course here outlined claims to do is quite another story and cannot be considered further here.

The reader, in attempting to evaluate the order of presentation of material as here considered, should bear in mind that the main objectives of the course under consideration are some appreciation of the following: the beauty of natural law as it may be discovered through a study of matter and energy, the methods employed by scientists in arriving at their present knowledge, the spirit which must motivate the search for truth about natural phenomena, the ever-incomplete knowledge challenging the worker of the present and

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* GLASOE, P. M., "A chapter in teaching acids, bases, and salts," J. CHEM. EDUC., **13**, 68–71 (Feb., 1936).

the future, and some development of the student's reasoning ability. These five—and the most important of these for the student who does not continue any work in chemistry as well as for the one who does, is the last!

INVERSION OF AN INTERESTING THREE-PHASE EMULSION

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IT IS well known that emulsions consist of droplets of one liquid dispersed in a second and that only two different emulsions are possible between a pair of given liquids. These binary emulsions are customarily classified as either "oil in water" or "water in oil" emulsions regardless of the exact chemical composition of the two liquid phases.

In addition to two-phase emulsions, there exist emulsions involving three immiscible liquids. The latter are more complex and less common, but it is not difficult to prepare them in the laboratory. There are

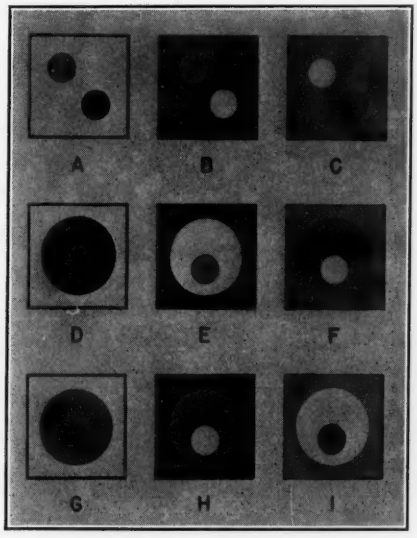

FIGURE 1

nine possible emulsions which may be formed in such systems, and these are represented diagrammatically in Figure 1. Unlike the binary emulsions which differ only by the composition of the dispersed and continuous phases, these emulsions differ in both the relative positions of each of the liquids and in the structure of the emulsion as a whole. In the first three, droplets of two of the liquids are suspended, side by side, in the continuous phase. In the last six, one of the liquids is separated from the continuous phase by the other.

Since there is this fundamental difference in structure between the two types of three-phase emulsions, it is not surprising to find corresponding differences in their properties in cases where an example of each type can be formed from the same three liquids. An illustration of this can be studied by repeating the following experiment.

Three liquids, xylene, methyl alcohol, and a saturated solution of potassium carbonate in water, are shaken together and allowed to reach equilibrium. For purposes of identification, the xylene may be dyed red with oil-soluble "Sudan III," and the water can be colored blue by adding a trace of copper sulfate. Equal volumes of each of the three resulting layers are then filtered into an eight-inch test-tube which is sealed to prevent evaporation. This results in the tube shown in Figure 2.

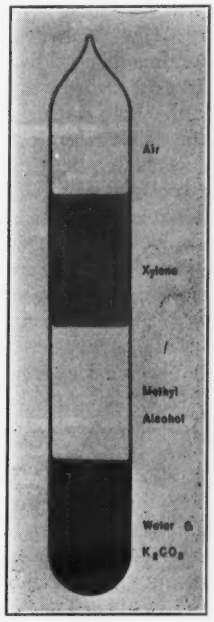

FIGURE 2

It will be found that the manner in which the tube is shaken determines the type of emulsion which is obtained. If the tube is shaken violently, from end to end, drops of water and drops of oil will be dispersed in the alcohol layer (Figure 1-A). If the tube is shaken gently, with a swirling motion, an emulsion is produced in which the water is dispersed in the alcohol and the alcohol is dispersed in the oil (Figure 1-I). It is quite easy to obtain the desired emulsion by starting with the quiescent condition and controlling the method of agitation. However, once a particular type of emulsion is formed, it tends to persist in spite of vigorous efforts to change it to the other type. Both the emulsions will break if they are allowed to stand for a few minutes, but they differ in the mechanism by which the liquids separate.

PRESENT TRENDS *in* GEOCHEMISTRY*

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THOSE who have read E. von Meyer's "History of Chemistry" will recall a few pages devoted to "mineralogical" and "geological" chemistry. These subjects have also long been recognized in different chemical abstracts. "Geochemistry" is a shorter term that was introduced, or at least used, by F. W. Clarke, formerly Chief Chemist of the U. S. Geological Survey, to cover about the same field. The "Traité de Chimie Minérale" by Moissan is really a general chemistry, though called mineral chemistry. Doelter's "Handbuch" is restricted more closely to mineralogy. Clarke assembled analytical and other fundamental information relating to geological chemistry in "The Data of Geochemistry," one of the best sellers ever published by the Geological Survey and often called the geologist's Bible.

What is geochemistry? It is really chemistry applied to geology, petrology, and mineralogy. This is a broad subject, ranging from the study of the abundance and distribution of the chemical elements in the earth's crust to the determination of their age, and it touches all of the earth sciences, as well as mining and agriculture. Some idea of its scope may best be given by noting present trends in certain special fields covered by the term.

COMPOSITION OF THE EARTH'S CRUST

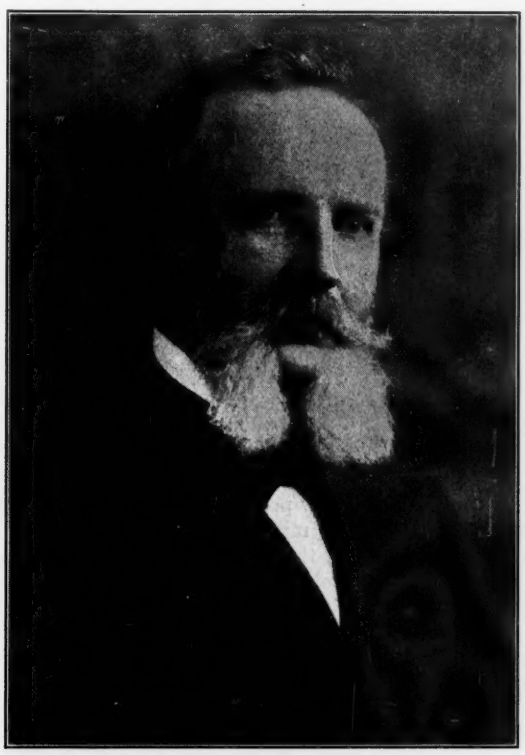
For light on matter under extreme conditions of temperature we turn to the astronomer, and similarly for behavior under extreme pressure we turn to the physicist, but the geochemist has restricted himself mainly to what is called the earth's crust, defined as all above a hypothetical surface ten miles below sea level. Two of the most interesting facts about each chemical element are where it is found and how much there is of it. The ancients were interested in these matters to a certain extent before elements were recognized as such, but generalizations became possible only with the development of good methods for the analysis of rocks. Determination of both the major and minor constituents of rocks was greatly perfected by Hillebrand and Washington. The determination of the less common elements involves separation from the excess of common elements; methods for such work are not generally taught in courses in analytical chemistry, though they are very necessary in geochemistry. Minor elements, such as boron, copper, and cobalt have also been found to be important in agriculture. Improved methods for fluorine, rubidium, and cesium have recently been developed in the United States Geological Survey and newer methods for many elements, such as cobalt, beryllium, lithium, molybdenum, and strontium have displaced those in use a decade ago. It is naturally difficult to arrive at an average distribution of the less common elements, but the safest way seems to be to proceed from their distribution in the common rocks, such as granite and andesite to the analysis of rare

FRANK W. CLARK (1847–1931)
DR. CLARK WAS THE AUTHOR OF "THE DATA OF GEOCHEMISTRY," UNITED STATES GEOLOGICAL SURVEY BULLETIN 770

* Presidential Address before the Geological Society of Washington, December 8, 1937. Published by permission of the Director of the Geological Survey.

minerals, and finally to make use of spectrographic and radioactivity methods.

For the rare elements the analytical methods are difficult and specialized, and some of these elements have been determined by only a few investigators in the whole world. Radium is one of the rarest of elements and yet on account of the vigorous ionizing power of its emanation extremely small quantities can be determined. In fact, the Geiger counter measures single atoms one at a time. Many of the rare elements are found only in pegmatites; consequently the estimation of their abundance in the earth's crust involves a knowledge of the ratio between the quantity of pegmatite and that of the associated granite. The question then arises whether the rare elements are extracted from a certain volume of granite or merely represent a segregation from the pegmatite, the pegmatite being essentially similar to granite in composition. Such questions make the abundance ratios of the rare elements rather uncertain. Another instance of uncertainty is found in rare elements associated with less common elements, such as gallium with zinc, rubidium with lithium, and so on. The abundance of the less common elements is measured directly, that of the rare elements is then referred through the less common elements to the earth's crust itself.



WILLIAM F. HILLEBRAND (1853–1925)
DR. HILLEBRAND WON RECOGNITION FOR HIS WORK IN ROCK ANALYSIS

Systematic figures on the abundance of the elements were first assembled in 1889 by Clarke, who calculated the average composition of the earth's crust by averaging analyses of rocks. Later, when geological surveys had supplied enough information on the distribution of different kinds of rocks other estimates were made, but with very similar results. The early figures included the ten most common elements. A second similar list for the abundance of fifty-five elements was published by Vogt in 1898 and included some of the rarest elements. Clarke and Washington made a new list of sixty-four elements in 1924. In this list hydrogen is raised in abundance from 0.17 per cent. to 0.88 per cent. A still more complete list was compiled by Fersman, the Russian geochemist, in 1932, covering eighty-eight elements. He raises hydrogen to 1.00 per cent. of the earth's crust, which, if the number of atoms is considered, makes hydrogen 5 per cent. of all the atoms of the crust. Still more recently the abundance of lithium has been raised from 0.005 per cent. to 0.065 per cent. We now have at least an estimate for the abundance of every known element, and are fast getting them for the different isotopes.

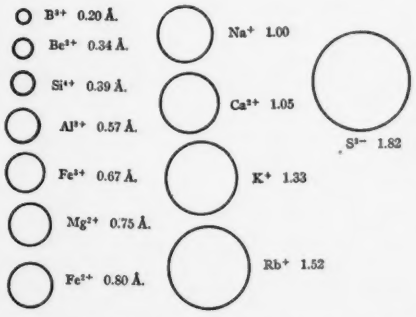


FIGURE 1.—RELATIVE SIZES OF ATOMS. THE FIGURES ARE IONIC RADII IN ÅNGSTROM UNITS

The discovery of isotopes—that is, elements having similar chemical properties but different physical properties—has widened the field of geochemistry considerably. We now know, for example, that not all rubidium is radioactive, but only one of its isotopes. Counting isotopes there are about two hundred sixty-two elements instead of ninety-two. Out of one hundred atoms in the earth's crust fifty are oxygen, twenty silicon, six aluminum, and five hydrogen, a total of eighty, leaving only twenty for sodium, iron, calcium, magnesium, potassium, titanium, and all others put together.

MAJOR PROBLEM

The major problem of geochemistry is to explain the origin of natural products. The chemist views nature

as a vast chemical plant, but he cannot penetrate to the seat of many of the operations and must deduce the conditions by analogy or extrapolation. Temperature, pressure, and concentration are the chief variables. The origin of some elements, such as lead and helium,

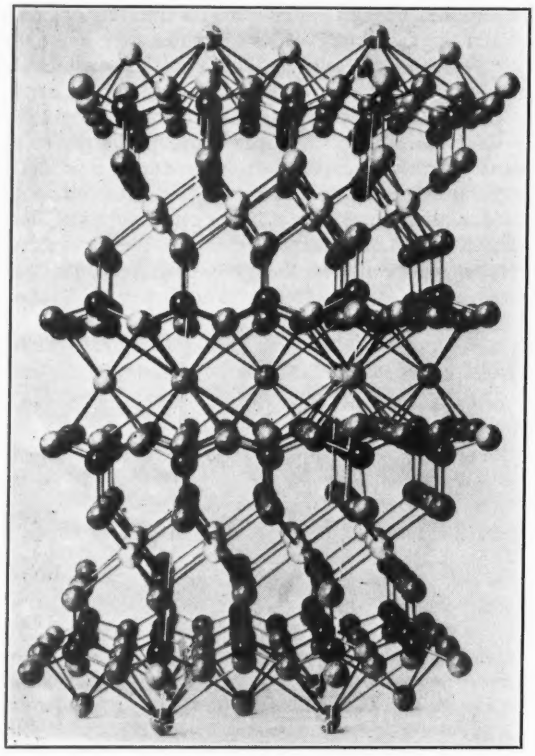


FIGURE 2.—THE STRUCTURE OF MICA (AFTER BRAGG). THE ATOMS HERE ARE REPRESENTED AS PRACTICALLY MATHEMATICAL POINTS. THE UNIT CELL IS OUTLINED BY THREADS AND ONE IS LOOKING NEARLY ALONG THE *b* AXIS. ONE SIGNIFICANT FEATURE IN THIS STRUCTURE IS THE INDEFINITE EXTENSION OF Si_4O_{10} GROUPS IN TWO DIRECTIONS

that of petroleum and many ore minerals, and even such common substances as clay is far from being fully understood.

MINERALOGY

The first aims of mineralogists were to describe minerals crystallographically and to analyze them chemically. Later they turned to the synthesis of minerals, led by the French school of mineral chemists. The Carnegie Geophysical Laboratory of Washington, D. C., has done outstanding work in this field. The fundamental importance of chemistry to mineralogy is shown by the fact that Dana's classification of minerals is based largely on their chemical composition.

In the days when physical chemistry was being rapidly formulated much attention was given to the relations between the chemical composition of minerals and their physical properties. One fruit of this study was the knowledge gained about the optical properties of crystals, results that were applied through the petrographic microscope as a rapid aid in the identification of minerals and the description of rocks based on thin sections. All this is fairly well systematized at the present time. The new emphasis is on the structure, that is, on the internal arrangement of atoms in crystals. Minerals are well adapted to such studies because, on account of the size of the crystals available, they afford correlations of the structure with cleavage, elasticity, and other physical properties, as well as with ordinary crystallographic properties.

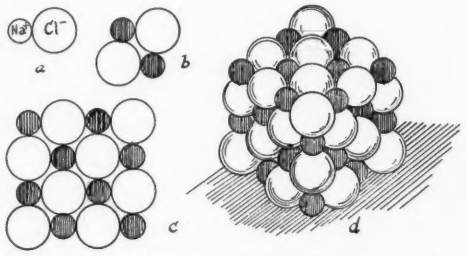


FIGURE 3.—DIFFERENT REPRESENTATIONS OF SODIUM CHLORIDE

Structure.—It is now possible to show that the physical properties of a mineral depend on the kind of atoms composing it, their chemical rôle and their arrangement. The volume of any one atom depends partly on its rôle, but the volumes of different atoms vary enormously. For example, six hundred thirty boron atoms might occupy the same space as one sulfur atom.

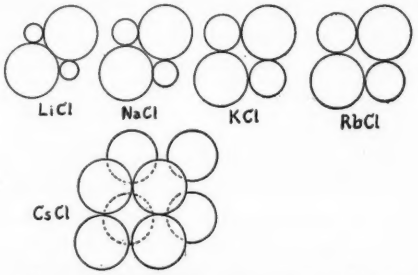


FIGURE 4.—REPRESENTATION OF THE STRUCTURE OF THE ALKALI CHLORIDES AND THE RANGE IN SIZE OF THE CATION

Many years ago T. W. Richards, known for his work on atomic weights, and with whom the writer had the good fortune to study chemistry, gave considerable study to the volume relations of atoms in different compounds, with special regard to compressibility. Results obtained with X-rays from 1913 on, however, reduced

what had previously been more or less speculative to a science. The arrangement and substitution of atoms is now seen to depend largely on the sizes of the atoms involved, and their arrangement can be determined by X-rays, as Pauling, the two Braggs, and others have shown.

The structure of crystals is usually represented by a system of points without any consideration of the size of the atoms (Figure 2), but it will be found when the architecture of crystals is considered that a close packing of the larger atoms is generally the rule.

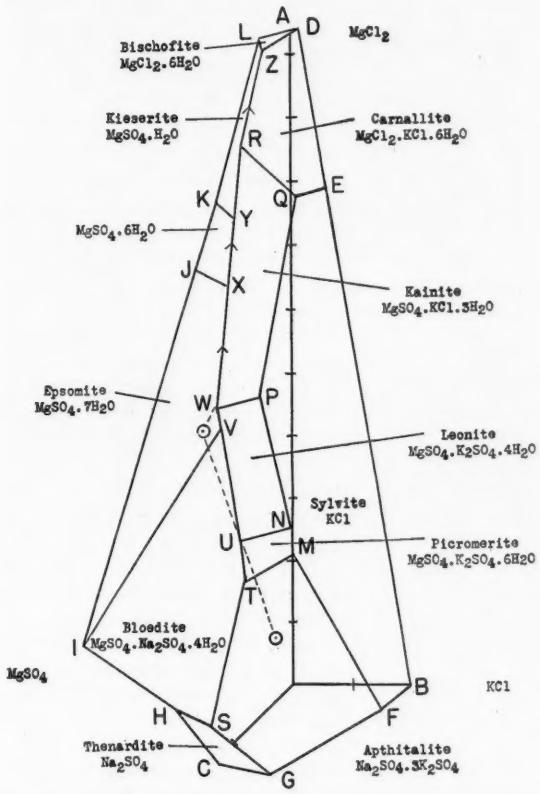


FIGURE 5.—COMPOSITION OF SOLUTIONS AND SALTS DEPOSITED IN THE EVAPORATION OF SEA WATER AT 25°C. (AFTER VAN'T HOFF, PRECHT, AND COHEN)

In Figure 3*a* we see that the proper relations of symmetry for a crystal of sodium chloride cannot be shown by two ions, or even by four or sixteen (*b* and *c*), but appear only in the solid model *d*. Figure 4 shows the relative sizes of the atoms in the five alkali chlorides and also calls attention to a shift in the structure of cesium chloride. The structure of the first four salts is similar with alternate cations and anions in the same planes, but that of the fifth, cesium chloride, changes to one resembling a pile of cannon balls, in which the cesium and chlorine ions are in different planes in three directions.

Table 1 gives merely one example of how a physical property, compressibility, depends on the structure of the material. In this table the "porosity" is the space calculated to exist between the atoms, assuming them to be perfect spheres arranged in their respective structures. The figures in parentheses are hypothetical

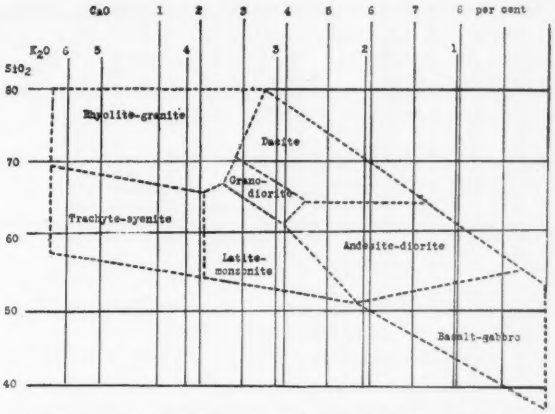


FIGURE 6.—CLASSIFICATION OF IGNEOUS ROCKS FROM THEIR CHEMICAL COMPOSITION. THE TWO NAMES REPRESENT EFFUSIVE AND DEEP-SEATED ROCKS, RESPECTIVELY

only, as the corresponding structures do not exist. Attention is called to the fact that the compressibility of cesium chloride is less than that of rubidium chloride, owing to the change of structure, and it is considerably less than it would be, apparently, if there were no change of structure. The cesium chloride structure is also seen to be the most compact of the group.

TABLE 1

ATOMIC STRUCTURE AND COMPRESSIBILITY

	NaCl structure		*CsCl structure*	
	"Porosity"	Compressibility $\frac{\Delta v}{\Delta p} \times 10^6$	"Porosity"	Compressibility $\frac{\Delta v}{\Delta p} \times 10^6$
	Per cent.		Per cent.	
LiCl	8.2	3.50	(45.7)	—
NaCl	32.4	4.18	(40.0)	—
KCl	44.0	5.65	(27.3)	—
RbCl	46.2	7.40	(19.0)	—
CsCl	(47.5)	—	4.8	5.9

PHASE RULE WORK

Phase rule studies, like those made by the Geophysical Laboratory, are an important part of geochemistry. Many minerals, however, can be formed in more than one way. It is more generally believed now than formerly that many rock-forming minerals have separated from complex solutions rather than from melts of simple binary or ternary mixtures. Just as barium sulfate can be transposed to barium carbonate by a solution of sodium carbonate, so one silicate mineral may be transposed to another far below its melting point. The solubility product and mass effects would determine the product rather than the melting point.

Much research remains to be done on such problems. It seems to the writer that the silica-alumina-lime-system should be studied further, starting with the excellent work of Shepherd, Rankin, and Greig, and continuing with solutions under pressure. Merwin's recent study of the copper-iron sulfides is an outstanding instance of phase-rule work.

Van't Hoff's phase-rule studies on the solubility of salts are well known. When applied to geology, however, as in the evaporation of sea water, certain additional features, such as the reactions of succeeding solutions on the salts first deposited, must also be considered. Table 2 shows the series of salts that are known to separate in succession as sea water is evaporated more and more; these are not necessarily the final products, however. The associations of minerals that may be expected to occur together are likewise indicated by the well-known phase-rule diagram of Figure 5. In this diagram the coördinates represent the composition of the solutions saturated with the different salts in terms of the compounds indicated. The mother liquors are supposed to be saturated with $CaSO_4$ and $CaCO_3$ throughout. On evaporation of sea water sodium chloride appears when the composition corresponds to the point in the circle just below and to the right of T. As evaporation continues more salt separates and the composition changes along the dotted line until the next circle is reached and epsomite separates. Further changes in composition are indicated by arrows.

TABLE 2

SALTS LAID DOWN IN THE EVAPORATION OF SEA WATER AT 25°C.

Density	*Volume*	*Mineral*	*Composition of solution to 1000 H_2O*					
			Na_2Cl_2	*K_2Cl_2*	*$MgCl_2$*	*$MgSO_4$*	*$CaSO_4$*	*$CaCO_3$*
1.0234	1000	Aragonite	4.122	0.087	0.591	0.319	0.151	0.037
1.122	200	Gypsum	20.6	0.44	2.96	1.60	0.50	0.007
—	—	Anhydrite	—	—	—	—	—	—
1.21	95	NaCl	49.0	1.03	7.02	3.79	0.08	0.003
—	—	NaCl, Polyhalite ?	—	—	—	—	—	—
1.29	19	NaCl, $MgSO_4 \cdot 7H_2O$ (epsomite)	13.0	5.7	38.5	20.8	—	—
1.31	—	NaCl, $MgSO_4 \cdot KCl \cdot 3H_2O$ (kainite)	7.5	7.1	49.0	18.4	—	—
—	—	NaCl, $MgSO_4 \cdot 6H_2O$, kainite	3.5	4.0	65.5	13.0	—	—
—	—	NaCl, $MgSO_4 \cdot H_2O$ (kieserite), kainite	1.5	2.0	77.0	10.0	—	—
—	—	NaCl, kieserite, $MgCl_2 \cdot KCl \cdot 3H_2O$ (carnallite)	0.5	1.0	85.0	8.0	—	—
—	—	Bischofite ($MgCl_2 \cdot 6H_2O$)	—	—	—	—	—	—

It is not likely that the immense beds of polyhalite found in Texas and New Mexico represent direct deposits from sea water. It is more logical to suppose that a bittern rich in magnesium chloride and potassium chloride acted on syngenite or anhydrite to produce polyhalite, as deduced, in fact, by Schaller and Henderson by a mineralogical study of certain specimens. But though single diagrams will not explain the origin of saline deposits or ore deposits the information is valuable in showing the associations to be expected at any given time; and any phase-rule work that is applicable to minerals may also have some industrial application.

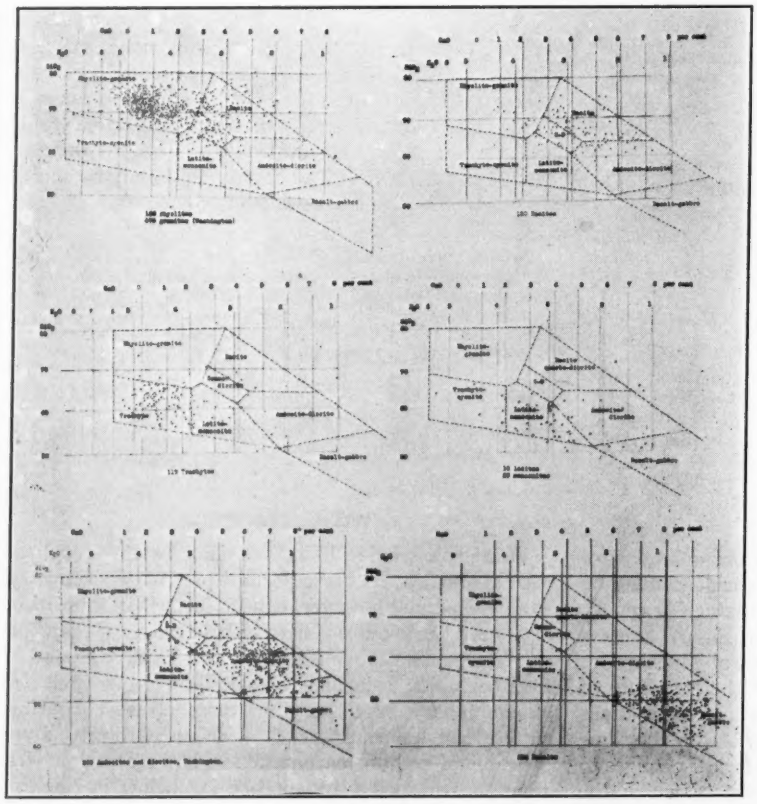
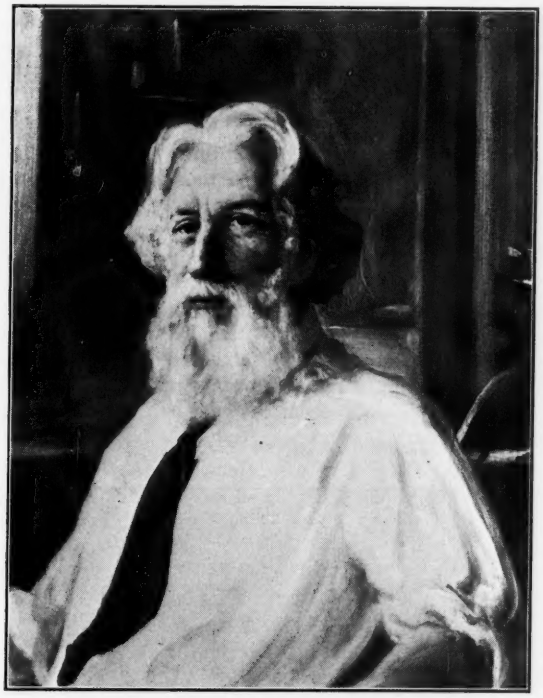


FIGURE 7.—CORRESPONDENCE OF NAMES OF ROCKS IN WASHINGTON'S PAPER WITH THE PROPOSED CHEMICAL CLASSIFICATION OF THE WRITER

PETROLOGY

Rock-forming minerals.—Rock-forming minerals are studied by

the petrologist from many different viewpoints, among which chemical composition is clearly an important one. It is now being increasingly recognized that certain rock-forming minerals are solid solutions of several components and can therefore be accurately described only by a generalized formula.



HENRY S. WASHINGTON (1867–1934)
DR. WASHINGTON WAS NOTED FOR HIS WORK IN ROCK ANALYSIS

The classification of igneous rocks.—There has been a decided tendency in recent years to get away from over-elaborate systems of classification of igneous rocks. Though not so evident to the eye as texture, the chemical composition of a rock, together with the mineralogical composition, if that can be determined, is a help to classification. Figure 6 presents a diagram that has been found useful by the writer in naming the common types of igneous rocks from their chemical analysis. This diagram may not give the correct name in every instance, but it helps to reduce overlapping and is especially useful with reference to the names of intermediate rocks and a few others. The first name in the different pairs applies to an effusive rock and the second to its deep-seated equivalent.

A point is located from an analysis with the SiO_2 percentage as ordinate and an abscissa halfway between the K_2O and the CaO percentages. The scales of the last two have been set arbitrarily to correspond with the composition of the main types of rocks involved. The final point is based therefore on three considerations, which seems a slight advance over the two generally used heretofore. The name of the rock is then determined by the area within which the point falls. Most of the chemical analyses listed in Washington's Professional Paper on the Chemical Analyses of Igneous Rocks under these names will fall in or near the respective areas of Figure 6, though some will fall outside or even at a considerable distance from the right area. The results are shown by the dots in Figure 7. Time has not permitted plotting the syenites. Grano-diorites (not shown) do not correspond very well with the area set apart for them, but it is believed that this area corresponds better with the name than the original definition of Becker.

TABLE 3

THE CONCENTRATIONS OF CERTAIN METALS NECESSARY TO FORM ORE DEPOSITS (AFTER SCHNEIDERHÖHN)

	A. Workable %	*B. Abundance* %	*Concentration factor A/B*
Iron	30.0	5.08	6
Nickel	1.5	0.018	80
Copper	1.0	0.010	100
Platinum	0.001	5×10^{-6}	200
Manganese	25.0	0.09	280
Zinc	8.0	0.017	470
Chromium	25.0	0.038	660
Lead	5.0	0.003	1700
Tin	1.0	6×10^{-4}	1700
Gold	0.001	6×10^{-7}	1700
Silver	0.05	6×10^{-6}	8000

VOLCANIC GASES

Volcanic gases have been repeatedly studied. In addition to steam they may include hydrogen, nitrogen, carbon monoxide, carbon dioxide, methane, sulfur, chlorine, silicon fluoride, and different volatile metallic compounds. As most of these gases might conceivably be formed or driven out when rocks melt there is little to be said in general about their significance. It is supposed that certain ore deposits originate from volatile gases or solutions set in motion by igneous activity, that is, by local heating or by unequal pressure. One feature in this connection is the effect of the gases, carbon monoxide and hydrogen, on ferric compounds. Their action on ferric oxide alone has been studied, but not that on ferric minerals. The decomposition of carbon monoxide to graphite can be predicted for certain temperatures and pressures.

ORES

Ores are formed in many different ways. The most-used ore, if one may term it ore, is coal, and petroleum is closely related to it. The geochemical problems involved in the origin of and changes in these two substances have occupied many investigators. One of the main geochemical generalizations concerning them was advanced by David White, formerly Chief Geologist of the United States Geological Survey, namely, that the fixed carbon content of coal rises with its degree of metamorphism and that no petroleum is found in regions where the fixed carbon ratio of associated coaly matter is higher than 61 to 63, pure coal basis.

There is not space to refer to all ores here. The present trend is to describe individual deposits in detail and apply chemistry either theoretically or practically. The metallic ores, though not produced in such quantities as the non-metallic ones, are more valuable, and their modes of origin have been studied rather fully.

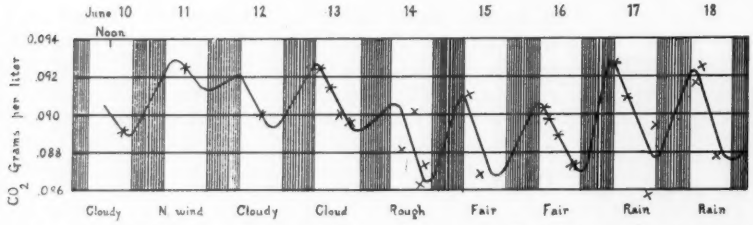


FIGURE 8.—DETERMINATIONS OF CARBON DIOXIDE IN SEA WATER MADE BY THE WRITER AT TORTUGAS, FLORIDA. THE DARK AREAS REPRESENT NIGHT AND THE LIGHT AREAS DAY. PLANTS CAUSE A DECREASE OF CO_2 IN LIGHT AND ANIMALS AN INCREASE OF IT AT NIGHT

Many ore-forming compounds have been synthesized, but it is certain that some of the experiments were not similar to natural processes. It is easier to reproduce natural temperatures than pressures. Some compounds have been made by simply pressing their constituents together, and it is now believed that "unequal" pressures are capable of effecting chemical changes that cannot be explained by uniform pressures. This is another way of saying that mobile constituents tend to escape through matter under pressure, if not sealed in by impermeable walls. This mode of transportation may have helped to fill mineral veins and openings in brecciated rock.

DECOMPOSITION OF ROCKS

In contrast to the chemistry of rocks and veins in inaccessible regions the processes that take place in the weathering of rocks go on under our eyes; still they are not entirely understood. We have the soluble products in lakes, rivers, and the ocean. Table 4 illustrates the climatic variations of river waters. The contributions of rivers to the ocean are under continuous observation in the Geological Survey and the totals, both soluble and insoluble, are becoming more accurately known each year. Experiments are now being made to see if oceanic sodium enters into a cycle to a much greater extent than heretofore supposed. Preliminary results indicate that it does, and if so the calculated age of the ocean will be greater and more in harmony with generally accepted figures. Other geochemical lines of investigation are illustrated by Figures 9 and 10 which are self-explanatory.

TABLE 4

CLIMATIC CHARACTER OF RIVER WATERS. PER CENT. OF TOTAL DISSOLVED CONSTITUENTS. 1. THE ST. LAWRENCE AT OGDENSBURG, NEW YORK. 2. THE MISSISSIPPI AT MEMPHIS, TENNESSEE. 3. THE COLORADO AT GRAND CANYON, ARIZONA. ANALYSES BY U. S. GEOLOGICAL SURVEY

	1	2	3
Ca	16.3	13.8	10.7
Mg	3.8	4.6	3.8
Na, K	3.3	7.3	13.2, 1.6
CO_3	1.5	—	—
HCO_3	61.0	49.5	21.2
SO_4	6.3	16.5	37.9
Cl	4.1	3.3	10.1
NO_3	0.2	0.6	0.6
SiO_2	3.5	4.2	1.9
Fe_2O_3	—	0.2	—
	100.0	100.0	100.0
Salinity	190	261	925
Suspended matter	Trace	519	11,900

The insolubles and precipitates that form sediments are becoming better understood through X-rays, dehydration curves, and tests of oil-bleaching power. Solubility measurements of the carbonate minerals are being made. The extensive study of the hot springs of the Yellowstone National Park by Day and Allen has thrown a flood of light on the transfer of heat by such waters. Radioactivity measurements on the sinters have been made by Schlundt to see if their age can be determined by that means.

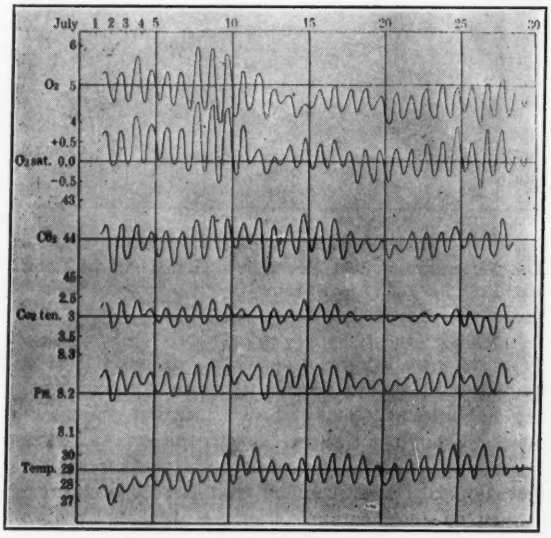


FIGURE 9.—DIURNAL VARIATION IN SEA WATER AT TORTUGAS DURING JULY, 1917 (AFTER MCCLENDON). THE TOP CURVE REPRESENTS ML. OF OXYGEN PER LITER, THE SECOND THE EXCESS OR DEFICIENCY OF SATURATION, THE THIRD ML. CO_2 PER LITER, THE FOURTH CO_2 TENSION, THE FIFTH pH, THE SIXTH TEMPERATURE

RADIOACTIVITY

Radioactivity is daily contributing new results with important geochemical implications. From a chemical viewpoint radioactive decomposition is a monomolecular reaction and follows the well-known equation for such a reaction. The rate of change for the ele-

ments that are of interest in connection with geologic time is slow. For example, in a *billion* years a given quantity of thorium would be reduced by only five per cent. of the quantity originally present, uranium would

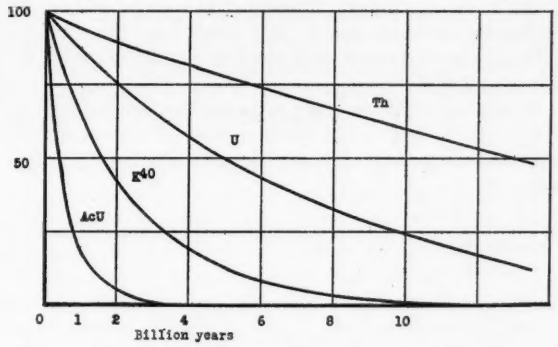


FIGURE 10.—DECAY CURVES OF FOUR ELEMENTS THAT ARE OF PARTICULAR INTEREST IN GEOLOGY. THE FOUR HALF-LIFE PERIODS MAY BE READ OPPOSITE 50

be reduced by thirteen per cent., K^{40} by thirty-four per cent., and actino-uranium by eighty per cent.

When the chemist analyzes a radioactive mineral he determines the percentage of radioactive elements still present and the final decomposition products; he hopes that all of the decomposition products have remained in the mineral and that there was not any of them in the original mineral when it was formed. From such results and the known rates of decomposition many interesting conclusions can be derived.

The writer will merely cite here three minerals that he has analyzed which throw some light on the geologic time scale in years, as calculated from lead-uranium ratios.

The first is a uraninite from Mexico. The specimen used was the freshest uraninite so far described. It is of post-Miocene age and the age calculated from the lead-uranium ratio is 33 million years. This result is without correction for ordinary lead, however, and no material for further study is available.

The second is samarskite from the Spinelli quarry east of the Connecticut River near Glastonbury, Connecticut. All that can be said of its geologic age is that it is pre-Triassic. Its age, not yet corrected for common lead, is calculated to be 375 million years, and this agrees with that calculated from an analysis of uraninite by Hillebrand and with one of monazite by Fenner, both minerals from the same district. This is the only instance so far known of three entirely different kinds of minerals from the same formation apparently agreeing in age as determined by genetic ratios.

The third mineral analyzed by the writer is Swedish kolm, an oil shale, which has been shown to be definitely of upper Cambrian age geologically. Its calculated age is 400 million years. From these results and Schuchert's relative ages for the different geologic periods a rough geologic time scale can be constructed. It does not depart much from Barrell's first scale, which was based in large part on Holmes' figures. Lack of space prevents a fuller discussion of this subject here.

The future, however, may possibly see some interesting developments in cosmogony based on radioactivity. It is evident, for example, that, as the radioactive elements are constantly decomposing, if we go back in time far enough, there must have been considerably more of them in the earth than there is today. In fact elements like K^{40} and AcU must have been present at first in much larger quantities than now. If so, they must have contributed heat at a greater rate, they must have generated their end-products, helium and lead, at a greater rate, and the changes have probably resulted in a contraction in volume. Arthur Holmes has recently written a paper on thorium and uranium as possible sources of ore-lead, at least in part.

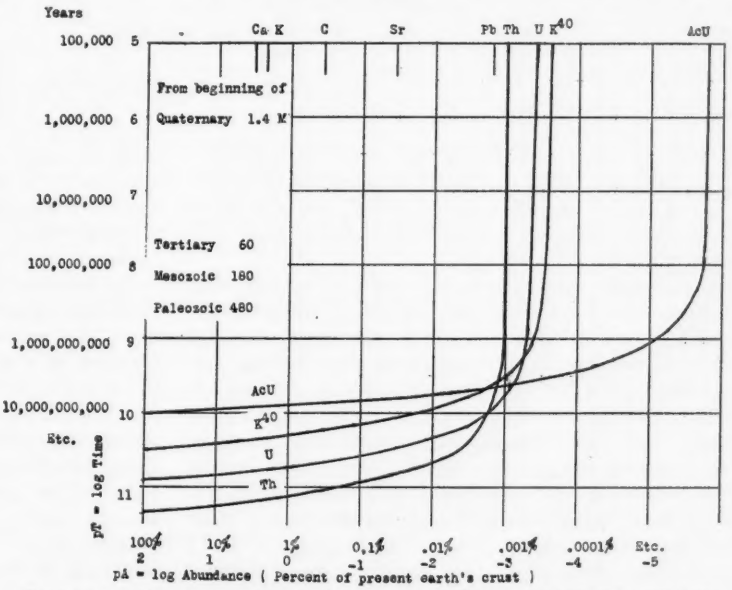


FIGURE 11.—RELATION BETWEEN ABUNDANCE OF CERTAIN ELEMENTS AND GEOLOGIC TIME. BOTH THE TIME SCALE AND THE ABUNDANCE SCALE ARE LOGARITHMIC. THE FIGURES FOR ABUNDANCE REFER ONLY TO THE "CRUST" OF THE EARTH, AND THE EXTRAPOLATIONS TO ONE HUNDRED PER CENT. ARE OF COURSE MORE OR LESS IMAGINARY

We must also consider AcU, an isotope of uranium, as a source of lead. In this field we must freely use imagination. Based on the present rates of decay calculation shows that there would have been enough of the radioactive elements in the earth three billion years ago

to have yielded all the lead now known (Figure 10). Consequently, it seems possible that even common lead may have been derived from the radioactive elements but was well mixed during the early geologic eras. It still remains to harmonize the atomic weight with this view. At any old age of the earth AcU would become of relatively great importance as a source of lead. These conclusions are all based on matter as we know it at the earth's surface, but on any premise the subject is of great interest. It is evident that simple extrapolation with time leads to a point of impossible or at least unexplained conditions. A logical assumption is that the earth is not so old that AcU, K^{40}, or even U were ever predominating constituents. One would have to go back 25 billion years to conclude that all Ca^{44} has been derived from K^{40}.

Like the biologist and botanist, who are able to create new species or varieties to a limited extent, the chemist is now busy making radioactive elements artificially and the results will doubtless throw much light on the structure and possible transmutations of the chemical elements.

In view of what has been presented in this paper one will probably grant that geochemistry, if not as broad a subject as geology, has its share of interesting problems.

WHAT OUGHT *to* BE *the* CONTENT *of* HEALTH MATERIALS *in* HIGH-SCHOOL CHEMISTRY TEXTS?*

J. O. FRANK

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IT IS, of course, trite to say that our views as to what constitutes valid materials and methods in the teaching of chemistry, are constantly being modified as changing conditions present new needs and make new demands.

High-school chemistry is especially concerned with the development of a citizenry capable of living intelligently in an environment in which chemicals, and chemical principles, play a part of ever-growing importance. Not the least important phase of living intelligently is the development and maintenance of good health, and chemistry, as well as most other sciences, has long included prominently all those principles and facts within its field, which have been considered of importance in the production and maintenance of good health.

It is the purpose of this paper to bring forward evidence, recently made available, which seems to indicate a need for extensive change in what has been considered the proper health materials for the high-school course of study in chemistry.

Most of what is said about the high-school course will apply with equal validity to the college course in general chemistry.

If we assume that high-school texts represent fairly accurately the course of study in the schools which use them, we can, by examining the content of texts, determine within limits what materials are treated in the course.

For purposes of this paper ten widely used high-school chemistry texts were examined. All were written or have been revised since 1931. All facts and principles thought to contribute to the health objective were extracted from each text and the materials tabulated and studied to determine extent of agreement, validity, accuracy, overlapping, completeness, and so forth. Many interesting and important facts were brought to light, only a few of which can be discussed in this paper, though much could be said about the numerous misstatements of fact, various definitions which were inadequate or wholly wrong, and similar items which make one wonder whether the authors of high-school texts are diligent in reading proof on their books.

It was found possible to segregate the health materials of high-school texts into two fairly well-defined fields. One body of materials includes all those principles and facts which relate to normal iving. Metabolism, breathing, the function of foods, water supply, chemicals as medicines, antiseptics, anesthetics, stimulants, and similar items are treated. This body of health materials has become fairly well standardized,

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and almost any high-school chemistry text will have a selection of items of this type which would be acceptable to most critics.

The other body of health materials consists of items which only occasionally or by accident might have to do with the maintenance of individual or public health. Presently this body of materials will be more clearly defined. It should be said now, however, that this paper is a plea for a better definition and a more adequate treatment of the various items in this field, the importance of which is very great.

CHEMISTRY AND ACCIDENTAL DEATH

There were more than 7000 accidental deaths in the United States in 1935,* in which chemicals were involved, or in which lack of chemical knowledge was a factor. There were probably at least 40,000 accidents of this kind since there are on the average six or more serious accidents for each fatal accident of this kind.

It seems clear that instruction in chemistry should have as one of its major objectives the prevention of accidents of this type and the reduction of this yearly death loss.

Information of considerable interest may be obtained from the Vital Statistics Reports of the Bureau of Census. (The last reports available are for 1935.)

DEATHS (ACCIDENTAL)

Due to absorption of poisonous gases	1665
Due to acute accidental poisoning (not gas)	1411
Due to food poisoning	709
Due to accidental burns in the home (not in fires)	3305
Total	7090

(*A*) *Absorption of Poisonous Gases.*—The average number of accidental deaths from this cause is well over 1800 yearly, over a period of the last five years. Carbon monoxide causes almost all of these deaths though a few are due to hydrogen sulfide, hydrocyanic acid, benzole, and ammonia.

The three most common sources of carbon monoxide in cases involving accidental death are:

(I) Illuminating gas.
(II) Automobile exhaust.
(III) Gas from coal stoves and heaters.

The chief sources of hazard from illuminating gas are:

(*a*) Leaky fixtures.
(*b*) Defective tubing (leading to stoves, irons, jets, or burners).
(*c*) Boiling over of liquids which extinguish the flame.
(*d*) Fixture turned accidentally.
(*e*) Tube or flexible pipe becomes detached from fixture.

The chief sources of hazard from automobile exhausts are:

(*a*) Running car in closed garage.
(*b*) Leakage of gas from defective manifold or exhaust pipe into the body of the car.
(*c*) Persons too close to exhaust of cars with motor going (presumably in open air of streets or alleys.)

NUMBER OF DEATHS FROM EACH CAUSE (ACCIDENTS IN INDUSTRY NOT INCLUDED)

	Year 1935	1934
Denatured alcohol	149	74
Barbital and derivatives	133	145
Strychnine	82	113
Arsenic	89	73
Wood alcohol	89	68
Kerosene	68	84
Corrosive sublimate	65	65
Lye (potash, etc.)	59	64
Lysol	41	49
Carbolic acid	42	44
Mercury (except $HgCl_2$)	24	32
Opium, morphine, laudanum	23	26
Hydrocyanic acid	18	19
Sodium fluoride	18	13
Carbon tetrachloride	12	10
Muriatic acid	11	7
Bromides	10	12
Paraldehyde	8	12
Gasoline	6	13
Nicotine	7	10
Lead acetate	—	12

The chief sources of hazard from gas from coal, oil, or charcoal heaters are

(*a*) Heaters operating in poorly ventilated room.
(*b*) Smoke pipe becomes disconnected.
(*c*) Drafts so set as to produce a quantity of carbon monoxide which is forced out into the room.

(*B*) *Acute Accidental Poisoning* (*Except Gas*).—Total deaths from this cause in 1935—1411 (average of about 1800 per year over a period of five years).

The following table shows the substances most commonly found to be the cause of death. (From a special tabulation by the Bureau of Census. Deaths from food poisoning, grain alcohol, snakes, scorpions, bees, spiders, and toxic gases are not included.)

Causes: (Origin of Hazard).

(*a*) About twenty-five per cent. due to mistaking poison for medicine. Mercuric chloride leads the list. Lysol, arsenic compounds, and carbolic acid also frequent.
(*b*) About twenty-five per cent. due to overdoses of medicine containing poisons. Atropine, veronal, acetanilide, opium, morphine, laudanum are frequently mentioned.
(*c*) About twenty-five per cent. due to mistaking wood alcohol or denatured alcohol for grain alcohol.
(*d*) About twenty-two per cent. result from young children getting medicines or poisons, mostly due to carelessness of parents or others. Strychnine, arsenic compounds, kerosene, lye, oil of wintergreen, phosphorus, hydrochloric acid, and acetic acid are most frequent causes.

* Not including deaths in industrial accidents.

TABLE SHOWING ADEQUACY WITH WHICH HIGH-SCHOOL CHEMISTRY TEXTBOOKS TREAT DANGEROUS CHEMICALS

(Based on the judgment of one examiner)

Text	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*Average*
Carbon monoxide	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	90
Illuminating gas	No	Yes / No	Yes	No	No	No	No	Yes	No	No	25
Auto exhaust	Yes	Yes	Yes	Yes	Yes	Yes / No	Yes	Yes	Yes	No	85
Stoves and heaters	Yes	Yes / No	Yes / No	Yes / No	Yes	No	Yes	Yes	Yes	No	55
Denatured alcohol	No	Yes	No	No	No	No	No	Yes	No	No	20
Barbital and derivatives	No	No	No	No	No	No	No	No	No	No	0
Strychnine	No	No	No	No	No	No	No	No	Yes / No	Yes / No	15
Wood alcohol	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	95
Arsenic compounds	Yes / No	No	Yes	Yes / No	No	No	No	Yes	No	Yes	40
Kerosene	No	No	No	No	No	No	No	No	No	No	0
Mercuric chloride	Yes / No	Yes / No	Yes / No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	80
Lye	No	No	No	No	No	No	No	No	No	No	0
Lysol	No	No	No	No	No	No	No	No	No	No	0
Carbolic acid	No	No	No	No	Yes / No	No	No	No	No	Yes / No	15
Sodium fluoride	No	No	No	No	No	No	No	No	No	No	0
Carbon tetrachloride	No	No	No	No	No	No	No	No	No	No	0
Bromides	No	No	No	No	No	No	No	No	No	Yes / No	15
Paraldehyde	No	No	No	No	No	No	No	No	No	No	0
Gasoline	No	Yes	No	No	No	No	No	Yes / No	Yes	No	25
Lead salts	No	No	No	No	No	No	No	No	No / Yes	No	0
Nicotine	No	No	No	No	No	No	No	No	Yes	No	10
Food poisoning	No	No	No	No	Yes	No	No	No	Yes	No	20
Approximate score	25	28	30	25	35	18	20	43	50	20	

YES / NO } Facts given, but no warning or statement of danger. NO / YES } Warning given, but facts are wanting.

(*C*) *Food Poisoning.*—Seven hundred nine deaths from this cause in 1935, and the yearly average over a period of fifteen years is about eight hundred in continental United States.

(*a*) Poisoning due to products of decay or growth of organisms in foods. "Ptomaines" were formerly supposed to be formed especially in canned foods left in the can for a time after first opening. It is now known that the poisoning was rarely due to the effect of the metal of the can. The food was either already dangerous when put into the can, or it spoiled on standing in the air. Many food products produce dangerous poisons as they putrefy.

(*b*) Mushrooms.

(*c*) Botulism and similar poisoning. (No detailed statistics available.)

BURNS IN THE HOME

There were 3305 deaths in 1935 due chiefly to the use of kerosene and gasoline in starting fires.

(No detailed statistics available.)

A VALID OBJECTIVE OF HIGH-SCHOOL CHEMISTRY

It is safe to assume arbitrarily that high-school chemistry is deeply concerned with the reduction of accidents due to chemicals or in which lack of chemical knowledge is a causal factor. Since the causes of more than 6300 fatal accidents in 1935 may be listed under only about twenty chemical names, a few texts may be easily examined to determine whether or not these items have been adequately treated. It will be assumed that adequate treatment consists of:

(*a*) The presentation of all essential facts, including especially mention of properties which may make the substance dangerous to human life.

(*b*) Special mention of the hazard involved through contact with the substance, under any conditions which may ordinarily or even occasionally be found.

If the above description of *adequate treatment* of a dangerous chemical item is valid, then the following table gives a fairly accurate indication of the adequacy with which the most important items have been treated in ten modern, widely used texts, the ability of one examiner to determine the facts being the only questionable factor.

In examining each textbook, the material presented under each item was considered twice; first, to determine whether all important facts were reasonably well treated, and second, to determine whether reasonable warning of danger was given. Answers were tabulated by items, and indicated by *Yes* or *No* according to the facts determined by very careful and thorough study.

CONCLUSION

There seems to be abundant evidence upon which to base the statement that high-school chemistry textbooks (as well as courses of study) *ought to include a*

COMPARISON OF WHAT SHOULD BE IN HIGH-SCHOOL CHEMISTRY TEXTS—AND WHAT IS FOUND THERE

Necessary Items in Adequate Treatment Carbon Monoxide	*What Is Found*
(A) Physical properties.	Most texts fair to good on CO.
(B) Chemical properties, including: How CO poisons—by reducing the oxygen-carrying capacity of the blood. It gives little or no warning. Also the toxic concentration—one part in 800 may cause death in thirty minutes, one part in 10,000 will produce symptoms of poisoning. Birds and mice used to detect it. "Hopelite" gas mask of value but ordinary military gas mask will not stop it. First-aid methods in cases of CO poisoning.	Highest score would be about eighty-five per cent. for best text.
(C) Occurrence and how produced.	One text does not mention CO except as a constituent of water gas. (Has two pages on heavy water, however.) Several texts only casually mention its toxic properties.
1. In illuminating gas. Kinds of accidents which make illuminating gas dangerous.* Precautions to be taken.	One text says another gas with warning odor *always* present—this is far from true. Several texts give no warning with illuminating gas. (Either of CO or explosions.)
2. In auto exhaust. Kinds of accidents from this source. In closed garages and in closed cars in the open air from leaking manifold or exhaust pipe. Standing too close to exhaust.	Most texts good in treatment of auto exhaust. Some give warning as though danger remote, however.
3. In mines. How produced and precautions.	Few texts give much on CO in mines. Many make no mention.
4. In stoves and heaters. How produced, and precautions which should be taken.	Some texts excellent. Others give no warning. Two texts mention fuel loss due to CO, but mention no danger to persons.
5. Other sources such as sewer gas, from drying paint or varnish in a closed room. Incomplete oxidation.	Only mentioned in one or two texts.
Denatured Alcohol Physical and chemical properties; uses. Mention that a *poison* is usually used to make unfit for use as a beverage. Wood alcohol usually used. Most denatured alcohol dangerous if used for rubbing alcohol—only special denatured alcohol should be used.	Most texts state that it is unfit for use as a beverage—but fail to mention its *poisonous properties* and to advise of danger in having it around.
Barbital and Derivatives Properties and kinds of medicines in which found. Warning against use of sedatives. Do not treat symptoms. Give information on number of casualties. Antidotes.	No mention. No warning.
Strychnine Properties and where used. Warning of dangers and advice to keep out of home at all times. Antidotes.	Mentioned in only one or two texts. No warning. No antidotes.
Wood Alcohol Chemical and physical properties. Warning of danger and statement of physiological effects. Internally, by fumes or through skin.	Most texts very good. Some excellent. Some say dangerous but fail to state why, or how it acts.
Arsenic Compounds Properties. Names of compounds ordinarily used, and how used. Warning of danger. Toxic amounts. Antidotes.	Only one or two have adequate treatment. Many *never mention* the poisonous nature of the compounds. Only one or two give warning of where used, and antidotes.
Lye (Alkali) Properties and uses. Warn against danger to children. Danger of external burns and by drinking solutions carelessly exposed. Antidotes.	Most texts mention caustic properties, but no special warning of danger to children. Few give antidotes.
Lysol Properties and uses. Stress danger of mistakes if kept in medicine cabinet. Antidotes.	No mention at all.
Carbolic Acid (Phenol) Properties and uses. Warning of danger if kept in medicine cabinet. Advise use of safer antiseptics or special container if used in home. Antidotes.	Not mentioned in several texts. Not mentioned as poisonous in some. No warnings at all in some.
Kerosene Not only chemical and physical properties, but stress danger if taken internally. Fire hazard. When warm gives fumes which are explosive; often generated when oil is thrown on hot coals.	None mention danger if taken internally. Almost no texts mention danger of explosive fumes.
Mercuric Chloride (Corrosive Sublimate) Properties. Stress extreme poisonous nature. State amounts used with safety as antiseptic. Danger if kept in home; of mistakes in use. Ordinary antiseptic tablets about twice a fatal dose. Urge use of other safer antiseptics instead. Antidotes. Calomel may decompose to produce the bichloride. Urge special marks on containers.	Most texts very good. Some only fair. Three fail to give adequate warning.
Carbon Tetrachloride Properties and uses. Warning that fumes are dangerous and substance dangerous when taken internally (in quantities of more than 4 or 5 cc.). Substance especially dangerous if taken internally by alcoholics.	No mention of danger from fumes or when taken internally.
Bromides Properties and uses. Warning of possible danger and especially of danger to children, who may pick up and swallow tablets left within their reach.	Most texts say only that KBr is used as sedative. No warning of danger. One text mentions only that it may upset digestion.

* See earlier part of this paper for list of types of accidents.

(*Continued*)

Paraldehyde Properties and uses. Warning of danger when used as sedative.	Not mentioned.	Lead salts dangerous in sprays if breathed. Lead chromate should not be used to color egg substitutes in baking, or paper which may come into contact with foods. Lead foil should never come into contact with moist foods, or foods containing acids.	
Gasoline Properties and uses. Mention of inflammability and explosive possibilities. Should warn of danger when taken internally—especially by children. Should mention special danger in the house. Ignition by pilot light of stove, static spark, etc. Warning against use in dry cleaning in house.	A few texts are excellent. Most texts have only fair treatment. Several texts say nothing of danger when taken internally.	*Nicotine* Properties and uses. Warning of poisonous properties. Antidotes.	Not mentioned in most texts. No warning.
Lead Salts Properties and uses. Lead soluble in soft water and many vegetable acids. Lead poisoning cumulative. Tetraethyl lead not dangerous as ordinarily used, but warning of danger if in contact with skin. Warning of gasoline containing tetraethyl lead. Lead poisoning may come from absorption of lead salts through the skin—from paints, powdered lead, etc.	Only a few warn of the poisonous properties of lead salts. None give adequate warning.	*Food Poisoning* Mention of all kinds of food poisoning. Poisons in foods due to organisms, metallic salts, decay, or putrefaction. Poison due to nature of foods or mistaking other things for foods, mushrooms, etc. Warning of dangers, how to prevent, and antidotes.	Texts put more stress on economic loss through putrefaction than on danger from poisoning. Little given on metallic salts or fruits as a source of danger. Botulism and mushroom poisoning *rarely* mentioned. One book does not mention putrefaction of foods at all.

large amount of new material which would tend to reduce the high mortality from accidents in which chemicals play a part.

It seems clear that all textbook authors ought to re-examine their books carefully, with a view toward improvement in the treatment of these chemical items reported by the Bureau of Census to be the cause of more than seven thousand accidental deaths in the United States in 1935. Surely high-school chemistry has some responsibility in this matter.

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PURDUE UNIVERSITY ORGANIZES SCHOOL OF CHEMICAL AND METALLURGICAL ENGINEERING

For many years past Purdue University has maintained an active School of Chemical Engineering, the enrolment of which has steadily increased. Early in the history of the School the practice of permitting some undergraduate specialization in chemical engineering and related fields was adopted; to give effect to this policy three options (general chemical engineering, organic technology, and metallurgy) were provided, each intended to furnish opportunity for upper class courses of instruction in the several specialties.

For a long time this arrangement was eminently satisfactory; in recent years, however, the increasing complexities of each of the fields of engineering has necessitated a reconsideration of the curriculum as the result of which it has become obvious that, related though they are, first-class instruction in chemical engineering and metallurgical engineering can be provided only by completely separating the courses of study.

This reorganization, which has just been completed, has resulted in the establishment of a School of Chemical and Metallurgical Engineering which will provide curricula leading to the degree of Bachelor of Science in Chemical Engineering, Bachelor of Science in Metallurgical Engineering, Master of Science, and Doctor of Philosophy.

The undergraduate student enrolment in the School in the present year includes approximately one hundred thirty seniors, of whom about thirty are majoring in metallurgy. In addition, between twenty-five and thirty graduate students are working in the School. The graduate and undergraduate enrolments represent a considerable increase over those of previous years.

The reorganization of the School has been made the occasion of revising the curriculum in chemical engineering. Changes in the latter have been in the direction of eliminating subject matter which is of doubtful pedagogical or professional utility, rearranging some courses to include new aspects of the field, expansion of some subjects to utilize increased laboratory facilities, and so forth. The metallurgical curriculum has been completely revised and greatly enlarged in content.

In both courses of study every effort has been made to emphasize the analytical approach, for it is felt that the ability to think is the only stock-in-trade that the engineer has to offer. Therefore, purely descriptive courses are kept to a minimum. Problems are freely utilized, not only to develop whatever reasoning ability the student may possess, but also to bring to his attention in a forcible manner many phases of his professional work.

Research work is being conducted by graduate students on thesis problems, by staff members in their respective fields (every staff member is expected to engage in research as a means of maintaining professional alertness and recognition) and industrially sponsored research fellows. Work on theoretical and of immediate industrial significance is encouraged among all these categories of research men; other things being equal, the theoretical problems chosen are those related to industrial progress rather than those of purely abstract nature. Problems which seek to utilize the specific personal experience or ability of individual members of the staff, or which utilize equipment which is available only at Purdue, are considered suitable for staff or graduate research.

Slightly more than $600,000 was made available a few months ago for the construction and equipment of a new building for the School. The work will be completed during the summer of 1939.

GIBBON, CHEMISTRY, *and* CHEMISTS

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EDWARD GIBBON, the great historian, was born April 27, 1737, and died January 16, 1794. During the past year attention has been directed to his bicentenary in various appropriate ways. It has not been emphasized, however, that Gibbon was interested in chemistry and, on occasion, exchanged letters with chemists.

In writing his famous "The History of the Decline and Fall of the Roman Empire," Gibbon had occasion to pay tribute to the chemist and engineer. Discussing the siege of Constantinople, he says, "In the two sieges, the deliverance of Constantinople may be chiefly ascribed to the novelty, the terror, and the real efficacy of the Greek fire. . . . . The skill of a chemist and engineer was equivalent to the succor of fleets and armies" (*1*).

As an historian, Gibbon was noted for his carefulness of preparation and precision of statement. He planned his work far in advance and prepared himself for the problems of research before they arose. He foresaw early the need of a better knowledge of chemistry than he then possessed. In continuing his discussion of Greek fire, he speaks from his own experience, "The historian who presumes to analyze this extraordinary composition should suspect his own ignorance and that of his Byzantine guides, so prone to the marvellous, so careless and, in this instance, so jealous of the truth" (*2*).

Like the true scholar that he was, Gibbon found it necessary, in order to interpret his data and evaluate the services of a chemist and engineer, to delve into chemistry. In his Memoirs he refers to the delay between the publication of the first and second volumes of his work. "Nearly two years had elapsed between the publication of my first and the commencement of my second volume, and the causes must be assigned of this long delay. After a short holiday, I indulged my curiosity in some study of a very different nature, a course of anatomy which was demonstrated by Dr. Hunter and some lessons of chemistry which were delivered by Mr. Higgins. The principles of these sciences, and a taste for books of natural history contributed to multiplying my ideas and images; and the anatomist and chemist may sometimes track me in their own snow" (*3*).

The Higgins here referred to was undoubtedly Dr. Bryan Higgins, M.D. At this time, *circ.* 1778, Higgins was a popular lecturer, and operated his own school of chemistry in London. Many social leaders, as well as literary people, attended his discourses. However, it is evident that these lectures of Higgins were not the only source of chemical information of which Gibbon availed himself. He apparently made a careful study of the "Chemical Essays" of Dr. Richard Watson, fifth Professor of Chemistry at Cambridge University and later Bishop of Llandaff. In a footnote in his "History," Gibbon refers to Watson's work as "a classic book, the best adapted to infuse the taste and knowledge of chemistry" (*4*). On other occasions he cites Watson as authority for certain information and views. He does this in connection with statements concerning the history of chemistry and in his more extended treatment on the discovery and military use of gunpowder. Concerning this latter topic he says, "The first and second volumes of Dr. Watson's 'Chemical Essays' contain two valuable discourses on the discovery and composition of gunpowder" (*5*).

Not only did Gibbon read Watson's essays on chemistry, but he also exchanged letters with him. This correspondence grew out of Watson's criticism of Gibbon's treatment of Christianity in the fifteenth and sixteenth chapters of the first volume of the "Decline and Fall." While Watson took vigorous issue with him on this matter, the discussion was carried on upon a high plane. Gibbon refers to his critic as "a prelate of a large mind and liberal spirit" (*6*). Further he says, "Dr. Watson's mode of thinking bears a liberal and philosophic cast; his thoughts are expressed with spirit, and that spirit is always tempered with politeness and moderation. Such is the man whom I should be happy to call my friend, and whom I should not blush to call my antagonist" (*7*).

Priestley, "the dauntless philosopher of Birmingham" (*8*), also took issue with Gibbon on these same chapters. The ensuing correspondence waxed acrimonious, and it is evident that Gibbon, while appreciating Priestley's contributions to chemistry, had no respect for him as a controversialist. Writing to him under the date of January 23, 1783, he says, "And, now, Sir—give me leave to convey to your ear the almost unanimous, and not offensive wish, of the philosophic world—that you would confine your talents and industry to those sciences in which real and useful improvements can be made. Remember the end of your predecessor, Servetus, not of his life (the Calvins of our days are restrained from the use of the same fiery arguments), but, I mean, the end of his reputation. His theological writings are lost in oblivion; and if his

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book on the Trinity be still preserved it is only because it contains the first rudiments of the discovery of the circulation of the blood" (*9*). A fortnight later, Gibbon answers the reply of Priestley in an unsuccessful attempt to close the correspondence, "It only becomes me to say, that the style and temper of your last letter have satisfied me of the propriety of declining all further correspondence, whether public or private, with such an adversary" (*10*). Priestley replied in like fashion merely, "Wishing to hear from you just as little as you please in private, and just as much as you please in public, I am, Sir, your humble servant" (*11*).

This is no place to evaluate the contribution of Gibbon nor to comment on the peculiarities and eccentricities of his character. Samuel Johnson, who nicknamed him "Monsieur Pomme de Terre," and others have done this. In a passing reference to the two hundredth anniversary of his birth it is interesting to note that he, like other literary scholars of the eighteenth century, studied and appreciated chemistry.

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The BALANCING *of* OXIDATION-REDUCTION EQUATIONS

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In the present article are outlined simple rules or steps by which equations involving elements or radicals showing a change in valence may be balanced easily and conveniently by students of first- and second-year college chemistry.

✦ ✦ ✦ ✦ ✦ ✦ ✦

DURING the past twelve years, numerous articles have appeared in the JOURNAL OF CHEMICAL EDUCATION (*1*) relative to the balancing of oxidation-reduction equations. Such a large influx of ideas into the literature is indicative of the importance with which the topic is regarded by teachers of chemistry.

The balancing of oxidation-reduction equations, though not particularly difficult, has long been a problem to students of general inorganic chemistry and qualitative analysis. Of the several methods available,* the *valence-change* method and the *ion-electron* method appear to be used very widely at the present time. Extensive theoretical treatment of the subject of oxidation-reduction may be found in any good book on electrochemistry. As for the merits of the two very popular present-day methods, as well as of other less widely used methods, the writer agrees with Deming (*2*) that "the ion-electron method probably has the greatest instructional value." Such a view is accepted by most chemists. Bennett (*3*) seems correct in thinking the method to be cumbersome for beginners. The approach used in the illustrations which follow is largely that of the valence-change method. Both

* BOTTOMLEY, JAMES, *Chem. News*, **37**, 110–1 (1878), in the paper, "Note on a method for determining the coefficients in chemical equations," outlines a mathematical method that should prove of interest to some students and teachers of chemistry.

An algebraic method by H. G. Deming is to be found in J. CHEM. EDUC., **11**, 125 (Feb., 1934).

methods, as pointed out by Hall (*4*) are really modifications of an idea of Johnson (*5*) which is more than a half-century old.

It is fortunate indeed that an extensive and comprehensive knowledge of sub-atomic phenomena is not essential in the balancing of equations. The conventional definitions for the terms *oxidation* and *reduction*, the realization that these processes involve the gain and loss of electrons by the *oxidant* and *reductant*, respectively, and the determination of *valence numbers* are fundamentals of which the average student of college chemistry is cognizant. A review of some of these fundamentals is, therefore, purposely omitted but rules for determining the so-called *valence-number* will be listed.

DETERMINATION OF THE VALENCE-NUMBER

1. For elements in the atomic state or in the molecular state, the number is zero.
2. The number for hydrogen in compounds of that element is always taken as *plus* 1 except in the hydrides of the highly electropositive elements such as lithium and sodium. In hydrides of this class, *minus* 1 is the number.
3. The number for oxygen in compounds of that element is always taken as *minus* 2 except in peroxides. In peroxides, the number is *minus* 1 per atom of oxygen.
4. For ions, the number will be the same as the charge associated with the ion.
5. The sum of the total charges of the elements in a compound is zero.

Hogness and Johnson (*6*) in their excellent text show the application of these rules in determining the valence-numbers of elements in simple substances.

BALANCING PROCEDURE AND APPLICATIONS

Step I.—See that the involved elements or radicals, *i. e.*, those exhibiting valence changes, are balanced atom for atom. Write over each of these elements or radicals the ionic valence-number and then indicate the total charge change in terms of electrons gained or lost. *Note:* If a substance that shows *internal* oxidation-reduction is present, write the formula for that substance twice and then apply Step I.

Step II.—Find the L.C.M. of the numbers representing the gain and loss. Make these numbers equal to the L.C.M. by appropriate selection of coefficient multipliers in order to conform with the conservation laws.

Step III.—Use ordinary means to complete the balancing of the equation.

Note: As the coefficients determined in the preceding steps are seldom changed, one usually has to adjust in Step III only those coefficients of incidental substances such as salts, water, acids, and bases, some of which may have a very marked effect on the pH of the solution.

A few examples will help illustrate the ease with which this *three-step* procedure may be employed in the balancing of oxidation-reduction equations.

(1) THE OXIDATION OF FERROUS SULFATE BY POTASSIUM DICHROMATE IN ACID SOLUTION

$$\overset{+6}{K_2Cr_2O_7} + 2\overset{+2}{FeSO_4} + H_2SO_4 \rightarrow \overset{+3}{Fe_2(SO_4)_3} + \overset{+3}{Cr_2(SO_4)_3} + K_2SO_4 + H_2O$$

loss 2 ϵ; gain 6 ϵ

Iron and chromium are the only elements exhibiting valence changes and the valence number of each is indicated over the corresponding symbols of the elements in the equation just written. The coefficient of 2 is used for the $FeSO_4$ since the involved elements must be balanced atom for atom at this point. The element iron changes in total charge (coefficient $\times$ subscript $\times$ valence-number) from plus 4 on the left to plus 6 on the right, a loss of 2 electrons. In changing in total charge from plus 12 on the left to plus 6 on the right, the chromium involved gains 6 electrons. Step I has now been applied fully to the equation.

Since the L.C.M. of 6 is the same as the number of electrons gained by the chromium on the left, no change of the coefficients is made of the substances in the equation which contain the element chromium. To make the electron-loss 6, the coefficients of the compounds containing the element iron must be multiplied by 3. The equation after finishing Step II is

$$K_2Cr_2O_7 + 6FeSO_4 + H_2SO_4 \rightarrow 3Fe_2(SO_4)_3 + Cr_2(SO_4)_3 + K_2SO_4 + H_2O$$

We now use ordinary means to complete the equation. Six of the thirteen sulfate groups on the right are accounted for by the $6FeSO_4$ on the left. The remainder of seven must be supplied by $7H_2SO_4$. In making the coefficient of the acid 7, that of the water is made 7 to complete the balancing. The balanced equation is now

$$K_2Cr_2O_7 + 6FeSO_4 + 7H_2SO_4 \rightarrow 3Fe_2(SO_4)_3 + Cr_2(SO_4)_3 + K_2SO_4 + 7H_2O$$

Another method which has been used in balancing the same equation involves the writing of the substances as mixed oxides and finding the number of atoms of oxygen gained and lost.

$$K_2O{\cdot}2CrO_3 + 2FeO{\cdot}SO_3 + H_2O{\cdot}SO_3 \rightarrow Fe_2O_3{\cdot}3SO_3 + Cr_2O_3{\cdot}3SO_3 + K_2O{\cdot}SO_3 + H_2O$$

gain 1 oxygen; loss 3 oxygens

To make the oxygen gain 3, there must be three times the amounts of ferrous oxide and ferric oxide already indicated. This is equivalent now to $6FeSO_4$ and $3Fe_2(SO_4)_3$. The equation is completed as above by inspection. One limitation of the method that seems evident is the difficulty in applying the procedure to oxidants and reductants not containing oxygen. In such cases, there would be the necessity of expressing certain constituents in terms of oxygen.

(2) THE REDUCTION OF SILVER ARSENATE BY ZINC IN THE PRESENCE OF SULFURIC ACID

$$\overset{+1+5}{Ag_3AsO_4} + \overset{0}{Zn} + H_2SO_4 \rightarrow \overset{-3}{AsH_3} + \overset{0}{3Ag} + \overset{+2}{ZnSO_4} + H_2O$$

loss 2ϵ; gain 8ϵ; gain 3ϵ; L.C.M. = 22

In this example, the elements silver, arsenic, and zinc are the only ones to change in valence number. The silver in the uncombined state on the right has the coefficient 3 in accordance with Step I. The silver changes in total charge from plus 3 on the left to (0) on the right, thereby gaining 3 electrons. The arsenic gains 8 electrons in its reduction to arsine and the zinc loses 2 electrons in changing in total charge from zero on the left to plus 2 on the right.

As the *total* electron gain is 8 plus 3 or 11 and the electron loss 2, the L.C.M. of 11 and 2 is 22. Continuing Step II, the gain is made twenty-two by using twice as much of the silver arsenate, arsine, and silver indicated in the previously written equation. To make the loss twenty-two, eleven is the multiplier for the Zn and $ZnSO_4$ coefficients. The equation is now

$$2Ag_3AsO_4 + 11Zn + H_2SO_4 \rightarrow 2AsH_3 + 6Ag + 11ZnSO_4 + H_2O$$

The $11ZnSO_4$ on the right will require 11 moles of sulfuric acid on the left. Since the $11H_2SO_4$ contain $22H$, $8H_2O$ will be needed on the right in addition to the six hydrogens already supplied by the arsine. The completed equation is

$$2Ag_3AsO_4 + 11Zn + 11H_2SO_4 \rightarrow 2AsH_3 + 6Ag + 11ZnSO_4 + 8H_2O$$

(3) INTERNAL OXIDATION-REDUCTION

$$\overset{0}{2P} + \overset{0}{P} + Ba(OH)_2 \rightarrow \overset{-3}{PH_3} + \overset{+1}{Ba(H_2PO_2)_2}$$

gain 3ϵ; loss 2ϵ; L.C.M. = 6

Since the reaction involves *internal oxidation-reduction*, *i. e.*, part of a substance is oxidized while another part is reduced, Step I provides that the substance (P in this case) be written twice for clarity. The gain and loss are then determined as in the preceding examples.

To make the loss equal 6, which is the L.C.M., 3 is the multiplier for the 2P on the left and the barium hypophosphite coefficient on the right. The gain is made 6 by using $2PH_3$ and two parts of the elementary phosphorus on the left with which it is connected by a line. We now have

$$6P + 2P + Ba(OH)_2 \rightarrow 2PH_3 + 3Ba(H_2PO_2)_2$$

The $3Ba(H_2PO_2)_2$ will require $3Ba(OH)_2$. To complete the balancing, $6H_2O$ must be added to the left side of the equation. In equations written in ionic form, it is permissible in certain instances to add hydrogen ion or hydroxyl ion to the appropriate side of the equation in balancing the final step. The final equation is

$$6H_2O + 8P + 3Ba(OH)_2 \rightarrow 2PH_3 + 3Ba(H_2PO_2)_2$$

In the oxidation of an ion that contains several elements that may show variable valences, there may be doubt in the mind of the beginner as to the appropriate valence-number to assign each element. It is probably best in such cases to consider the ion as a unit. This is illustrated very nicely by Simons (*7*) in considering the oxidation of thiocyanate by permanganate in acid solution. The partial equation involving the reductant, CNS^-, is

$$\underset{(-2)}{2CNS^-} \rightarrow \overset{+4}{\underset{(+8)}{2CO_2}} + \overset{0}{\underset{(0)}{N_2}} + \overset{+6}{\underset{(+12)}{2SO_4^{--}}}$$

The coefficients used in the partial equation just written balance the C, N, and S as provided by Step I. The numbers in the parentheses indicate the total charge involved, the sum of the total charges on the right being plus 20. The change in total charge from minus 2 on the left to plus 20 on the right means the loss of 22 electrons.

In applying the steps outlined to equations involving the action of nitric acid on copper, more nitric acid must be used in the final balancing than indicated after the application of Step II. The extra acid represents that *not* reduced by the metal.

The beginner will find it advantageous to apply the steps separately as done in the preceding examples. With considerable practice, the proficiency of the student will be such that the automatic though consecutive application of the steps may be made on one writing of the equation. The *three-step* procedure may be used, too, in equations where some or all of the substances are written in ionic form. It is apparent that compensation must be made for water in instances where hydronium ion appears in the equation.

The more ambitious student will do well to study the monograph by Jette (*8*) which affords a thorough treatment of oxidation-reduction reactions including emphasis on the means by which the products of such reactions are determined.

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(2) DEMING, H. G., "Balancing equations algebraically," *ibid.*, **11**, 125 (Feb., 1934).

(3) BENNETT, C. W., "Balancing equations by the valence-change method," *ibid.*, **12**, 189–92 (Apr., 1935).

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TIME *to* RETIRE*

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As the science of chemistry progresses, new material is constantly added, but there is an apparent reluctance to discard any old material. Several outmoded processes and unsatisfactory concepts still used in our teaching are herewith proposed for discard.

✦ ✦ ✦ ✦ ✦ ✦

ONE of the major problems that always confronts us as chemistry teachers is the rapidity of the changes in the science as we teach it. We have to modernize our courses continually, not just occasionally. We have to keep abreast of the times. There are occasions, of course, when this need for modernization is particularly stressed, as, for example, at the "Symposium for Modernizing the Course in General Chemistry" of the Division of Chemical Education at the eighty-eighth meeting of the Society at Cleveland in 1934. From the contributions to that symposium, and others published from time to time, we receive the necessary stimulus to keep our courses modern.

All of these changes involve the addition of a lot of material, so much so that someone has aptly said that our courses suffer from "additionitis." We seem to be pretty well agreed on the fact that additions *should* be made, and partially agreed on *what* we should add. But we fail, perhaps, to get together on what we should leave out. After all, we cannot add indefinitely to the content of our courses, especially the introductory courses in general chemistry. In the procedure of modernization, some things are automatically eliminated. But not all of them are. There are many concepts and processes which we teach today that could be safely dropped. It is time to retire them. If we, as teachers, could agree on at least a few of these items, we could then make room for some of the new things. It is not the purpose of this paper to list everything that should be retired, but to propose only a few of the more obviously outmoded processes and unsatisfactory concepts. No doubt they will suggest others.

The first topic that I would urge for elimination from the general chemistry course is the arc process for the fixation of nitrogen, the so-called Birkeland-Eyde process. This apparently is an industrial process that many of us like to teach. It appears in a number of texts and syllabi, even in recent revisions.[1]

Of the various methods of fixation of nitrogen usually studied in an introductory course, it is the most spectacular, and certainly the easiest to teach. The students like it because it involves the fewest equations, all of them simple and "easy to balance." The process is not only spectacular, but easily demonstrable. Evidence for its popularity among teachers is offered by the appearance in recent years of a number of excellent papers which describe lecture demonstrations of it.[2]

Because of our liking for it, and the consequent emphasis placed upon it, the student gets the idea that it is the most important method for the fixation of nitrogen. Even if he doesn't get this idea, he will acquire a conception of it which is all out of proportion to its real importance. For despite the fact that on paper or blackboard or lecture demonstration table it looks like a good process, it is of no commercial significance whatever today. At no time has it attained the importance that we teachers have given it. There has been only one plant that has successfully produced nitric acid by the arc process, and that is a plant in Norway. The maximum production of this plant was 45,000 tons in 1915. There were a few other plants, but these, for all practical purposes, never got beyond the experimental stage. Today these plants have all been changed to produce fixed nitrogen by the ammonia process. The method is considered obsolete today.[3] I propose, therefore, that we retire this process to the histories of chemistry, where it properly belongs.

Another time-honored process that I would relegate to limbo, or at least to those same histories of chemistry, is the LeBlanc process for the manufacture of soda ash. This appears to be another process from which we hate to part. In several texts today the method is given as much space as the present-day Solvay process, although it is pointed out that the method is obsolete. It is still included in some syllabi. This indicates that we are still teaching the LeBlanc process, for if we as teachers didn't want to teach it, it would quickly disappear from the texts. Suppose we agree to retire it. It has never been used at all in this country, and where it has been used it is now obsolete. According to one authority,[4] "LeBlanc's process for soda ash manufacture has now disappeared. . . . .[it has] sunk into oblivion." But it hasn't done so in our high-school and

* This paper was presented in part at a meeting of the Lehigh Valley Section of the American Chemical Society, February 19, 1937.

[1] *Cf.* BAKER, book review of "An introduction to college chemistry" by H. T. Briscoe, J. CHEM. EDUC., **14,** 399 (Aug., 1937), and book review of "Smith's inorganic chemistry" by James Kendall, J. CHEM. EDUC., **15,** 49 (Jan., 1938).

[2] ZUFFANTI, "Demonstrating the fixation of nitrogen," *ibid.*, **14,** 73 (Feb., 1937).

THIESSEN, "Improved apparatus for demonstration of fixation of atmospheric nitrogen," *ibid.*, **10,** 498 (Aug., 1933). This contains reference to three other papers on the same topic.

[3] ROGERS, "Industrial chemistry," 5th ed., D. Van Nostrand Co., Inc., New York City, **1931,** Vol. 1, pp. 326–8.

[4] Ref. 2, p. 239.

college chemistry courses. I believe that this is another topic we should agree to retire.

Besides these two obsolete industrial processes, it might be well to consider some of our obsolete theoretical concepts or ideas. There are some of these which should be retired. We may not find unanimity of opinion here, but I am going to suggest one or two of these which seem to survive, despite a preponderance of evidence against them. At least they still appear in some texts and courses of study. One of these older concepts that seems to have taken a firm root is the "nascent" element idea, *e. g.*, "nascent" hydrogen and "nascent" oxygen. Over ten years ago, Kendall[5] proposed that this idea of the "nascent" state be discarded. Any reactions of this type are more satisfactorily explained as an electron exchange mechanism in oxidation and reduction, and as due to differences in the energy changes involved. But the idea still persists, in our courses, in our texts. Couldn't we retire it?

In the same category are some of the ideas regarding the process of "combustion." The study of oxygen has apparently grown up around the idea of combustion, and it seems impossible to separate the two. A widely used high-school syllabus has these typical statements under the properties of oxygen: "(*a*) Oxygen is not combustible; (*b*) Oxygen is a good supporter of combustion." It takes a lot of teaching to students who have learned this to get across to them the idea that the wood that burns in oxygen "supports" the combustion as much as the oxygen. These same students are terribly shocked when they find out that oxygen isn't necessary for combustion after all. We would do better simply to teach combustion as a splendid example of a very rapid reaction; the misconceptions could be retired.

We as teachers are probably responsible for another bad definition that should be dropped, that of the saturated solution. The old definition, "a saturated solution is one which holds all of the solute it can at a given temperature" is still with us, believe it or not. It is much better to teach the concept of a saturated solution as one which involves an equilibrium between dissolved and undissolved solute. But once a student has learned the former definition, try to make him learn the correct one! The poor definitions seem to stick better than the good ones, if they happen to arrive in the student's mind first. So why not leave out the poor ones?

This whole topic of solutions, especially solutions of electrolytes, is at the present time in a particular state of confusion. Naturally, this is due to the present rapid rate of change of the theory. This requires that we teachers be continually on the alert to present the newer ideas as fast as they are accepted. But, as we add the new ideas, we must be careful to subtract the old ones that are no longer necessary. We can present the modern ideas of strong electrolytes under the special topic of ionization, but we also ought to use them throughout the rest of our course. It worries the students when we teach them about complete ionization in the lessons on ionization, and then later on present reactions occurring in water solution as molecular reactions. Or when we have them learn about hydronium ions in the lesson on acids and bases, and a few weeks afterward begin to talk about hydrogen ions. One of our difficulties here is that we haven't yet agreed on a common course of action. The acid-base nomenclature is an example. What are we going to call the acid ion in water solution? Shall we call it the "hydronium" ion, the "oxonium" ion, the "hydrated hydrogen" ion, or just plain "hydrogen" ion? Here is the situation many students are in today. In the chapters on acids and bases in their general chemistry text they get "hydronium" ions. Later on in the same text they get "hydrogen" ions. Following that in qualitative analysis they have the term "oxonium" ions; then in quantitative analysis they get back to "hydrogen" ions. It worries them, and it should. We ought to agree very shortly on which term is the one we want to use, and then discard all of the others as rapidly as possible. My personal preference is for the term "hydronium" ion, if we are going to use the newer concepts at all. But, in any event, let us select one term, and stick to it. In this connection there are many problems of nomenclature; we should try, however, to be as uniform as possible, and to eliminate all of the old terms that we can. When we don't, confusion results.

Finally, I would suggest that we retire the "World War." To many of us, it is "The War." To most of us it stands out as a vivid experience, whether we saw service in the trenches, or had a job in Washington, or merely marched around the athletic field between classes under the watchful eye of S. A. T. C. lieutenants. Because of our experiences, we are perhaps inclined to draw upon "The War" for a lot of our examples in teaching. But to our students it isn't nearly as exciting, or interesting; it was something that happened before they were born. We do need to talk about wars when we talk about chemistry; we can use illustrations from the World War. But when we use those illustrations, we should present them from the student's viewpoint, not our own. It would be more timely to take our illustrations from the present wars, or perhaps more appropriately, from the next war. If we do not entirely retire "The War," let us at least keep it in its proper perspective.

We have here proposed only a few topics that should be retired. Certainly there are many others that should be included, but, as we stated in the beginning, it is not the purpose of this paper to include them all. The reader will certainly think of others that he would add. Perhaps at some future time we could have another symposium on modernizing the course in general chemistry. But this time it could be organized around the idea that we modernize by subtraction, that we try to reach some agreement on the topics that it is now time to retire. Certainly such agreement would be helpful to all of us.

[5] KENDALL, "Smith's inorganic chemistry," The Century Co., New York City, **1926**, pp. 273, 592.

The PREPARATION *of* DISODIUM HYDROGEN PHOSPHATE—*an* EXPERIMENT *for the* FRESHMAN LABORATORY*

GEORGE W. WATT AND W. A. FELSING

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IN THE course in general chemistry at The University of Texas, the subject of normal solutions receives considerable emphasis. As compared with similar courses in other schools, the treatment of this subject matter differs, perhaps, only in the extent to which the classroom work is supplemented by suitable laboratory exercises. Although designed primarily for use in this connection, the experiment described below has been found of value for other reasons which will be apparent from a consideration of the nature of the questions and problems which follow the outline of the procedure.

The major portion of this exercise can be carried out conveniently in a two-hour laboratory period, and only a small part of the succeeding period is required for its completion. The use of this experiment naturally requires a careful consideration of the student's prior training and experience in the laboratory. The details of the work already covered by students who have performed this experiment will not be discussed here, since this information may be secured elsewhere.[1]

The directions for performing the experiment are given to the student in essentially the following form.

Purpose: (*a*) To study the partial neutralization of phosphoric acid and to prepare disodium hydrogen phosphate. (*b*) To provide further exercise in carrying out several operations commonly employed in the chemical laboratory. Particular attention should be directed toward the following operations: (1) the weighing out of a sample of a liquid; (2) the quantitative transfer of a liquid from one container to another; (3) the concentration of an aqueous solution by the application of heat; (4) the crystallization of a substance from its aqueous solution; and (5) the quantitative transfer of a solid from one container to another.

Procedure: Secure one 50-cc. buret from the storeroom and cleanse it thoroughly. Rinse the buret twice with 5-cc. portions of the sodium hydroxide solution† on the desk reagent shelf. Finally fill the buret with this sodium hydroxide solution.

In a graduated cylinder, measure out 10 cc. of eighty-five per cent. phosphoric acid‡ from the large bottle on the side shelf. Using as much of this volume as is necessary, weigh out a 15-g. sample of the acid into a 50-cc. beaker. The weight of sample need not be exactly 15 g., but should be between 14 and 16 g. and its weight must be known to the nearest tenth of a gram. In weighing out this material, observe the precautions and points of technic pointed out by the laboratory instructor in the discussion at the beginning of the laboratory period. Above all, do not spill the acid on the balance pan. Transfer the acid as completely as possible to a 250-cc. beaker containing 60 cc. of distilled water. In order to transfer the film of acid adhering to the walls, rinse the smaller beaker twice with 5-cc. portions of distilled water, and add these washings to the contents of the larger beaker.

Add *two* drops of methyl orange indicator solution to the acid and titrate with the sodium hydroxide solution in the buret. The color change at the "end-point" will be from pink to pale yellow. Record in the laboratory notebook the volume of sodium hydroxide solution required. This volume is that required for completion of the reaction,

$$H_3PO_4 + NaOH \longrightarrow H_2O + NaH_2PO_4,$$

i. e., that volume required for the one-third neutralization of the phosphoric acid solution taken as a sample. To prepare disodium hydrogen phosphate, however, two-thirds of the replaceable hydrogen in each molecule of this acid must be neutralized.

To the solution in the beaker now add an additional volume of sodium hydroxide solution from the buret *exactly* equal to the volume used in the above titration, thereby displacing one more of the available hydrogen atoms,

$$NaH_2PO_4 + NaOH \longrightarrow H_2O + Na_2HPO_4$$

The solution in the beaker now contains disodium hydrogen phosphate, and the problem is to obtain this

* Presented by title at the ninety-fifth meeting of the A. C. S., Dallas, Texas, April 21, 1938.

[1] SCHOCH, E. P. AND W. A. FELSING, "General chemistry," McGraw-Hill Book Co., Inc,. New York City, 1938.

† Approximately 5*N*.

‡ Either the C. P. or U. S. P. grade may be used.

salt in the crystalline condition from the aqueous solution.

Heat the beaker and contents until the solution has been concentrated to one-third of its original volume. During the last stages of the evaporation, it will be found necessary to stir the solution in order to prevent superheating.

Cool the concentrated solution (with stirring) either by allowing tap water to flow over the lower part of the beaker, or if necessary by cooling (with stirring) in a bath of ice-water.

Filter off the crystals which separate. Wash out the last traces of salt from the beaker with 5-cc. portions of the *filtrate* making certain that *all* of the solid has been transferred to the filter. Allow the filtration to proceed as long as any appreciable separation of solid and solution occurs. Transfer the crystals from the filter to a *weighed* watch glass and spread out the solid so that it may dry readily. Allow this to dry until the next laboratory period. When the salt appears to be dry, weigh the crystals and watch glass and record this weight.

Questions and Problems: (1) What weight of disodium hydrogen phosphate was obtained?

(2) Write *one* equation representing the formation of disodium hydrogen phosphate from phosphoric acid and sodium hydroxide.

(3) On the basis of the above equation, what weight of disodium hydrogen phosphate was actually formed from the weight of *hydrogen phosphate* used (Wt. of H_3PO_4 = 0.85 × Wt. of sample)?

(4) Compare the values obtained in (1) and (3). How may the difference (if any) be accounted for?

(5) Knowing the weight of disodium hydrogen phosphate formed in the reaction and the weight actually isolated from the solution, calculate the "yield" in terms of per cent.

(6) Knowing the volume of sodium hydroxide solution required for the one-third neutralization of a given weight of eighty-five per cent. phosphoric acid, calculate the normality of the sodium hydroxide solution on the desk reagent shelf.

(7) If, in separating from the aqueous solution, disodium hydrogen phosphate crystallized with 12 molecules of water of crystallization, in what manner will this influence the results obtained in (1), (4), and (5)?

(8) Recalculate the "yield" in terms of the product having the formula, $Na_2HPO_4 \cdot 12H_2O$.

(9) Write the equations for the stepwise neutralization of phosphoric acid. Combine (add) the three steps in order to obtain one equation representing the complete neutralization.

(10) If the formula, Na_2HPO_4, represents *disodium hydrogen phosphate*, what names should be given to the salts having the formulas, NaH_2PO_4 and Na_3PO_4?

(11) If, after concentrating the solution to one-third of its original volume and cooling, no solid separated, what procedure should be used in a further attempt to secure crystals of the dissolved salt?

(12) In transferring the crystals from the beaker to the filter, the directions specify that the last traces of the salt should be rinsed out with 5-cc. portions of the *filtrate*. Why not use water for this purpose?

When the use of this experiment was first contemplated, the fact that the formation of acid salts had not yet been discussed loomed as a serious objection. Experience has shown, however, that this situation does not detract from the value of the exercise. Furthermore, it has been found that the later discussion of the nature and formation of acid salts is markedly facilitated with students who have previously carried out this particular experiment.

As was anticipated, the yields obtained by students of so limited experience were subject to wide variations. In recalculating the yield in terms of the dodecahydrate, no attempt was made to recognize the probable partial dehydration of this material.

The experiment has been used with large numbers of beginning students with uniformly satisfactory results. It is felt that while perhaps certain objectionable features must be recognized, the manner in which the experiment so obviously illustrates fundamental principles and at the same time provides a means of developing manual dexterity on the part of the student serves to recommend its use.

Although probably more costly than many experiments used in the freshman laboratory course here and elsewhere, the cost per student is by no means prohibitive. If desired, the student preparation may be collected for subsequent purification and use in the preparation of buffer solutions or for other purposes.

CORRESPONDENCE

APPARATUS FOR SPECTROSCOPIC ANALYSIS

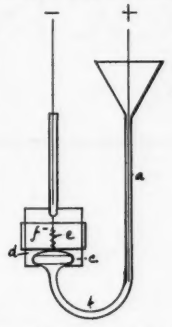
To the Editor

DEAR SIR:

Enclosed find a set-up for spectroscopic analysis, by means of which the solutions to be examined may be readily changed and the container cleaned.

It is made by bending a long-stemmed funnel *a*, as at *b*, and flaring out the lower end as at *c*. The solution containing also hydrochloric acid heaps itself up at *d*, so that a sufficient supply is present to steady the spark and prevent it from contacting and perhaps breaking the container.

The slit of the spectroscope is shown behind the spark, *e*, and should be far enough away to prevent corrosion of the metal composing it. These pieces should be made easily removable so that they may be cleaned.



The old solution is removed by running acidulated water from a reservoir, not shown, through the funnel. This spurts upward and cleans not only the funnel, but also the platinum electrode, *f*.

This set-up will definitely determine, manganese, zinc, barium, strontium, calcium, and magnesium, as well as sodium and potassium, even in the presence of each other. Any acidulated boron compound will reveal itself, by broad bands extending clear across the field, with a certainty contrasting with usual methods of flame or turmeric.

E. E. CHANDLER

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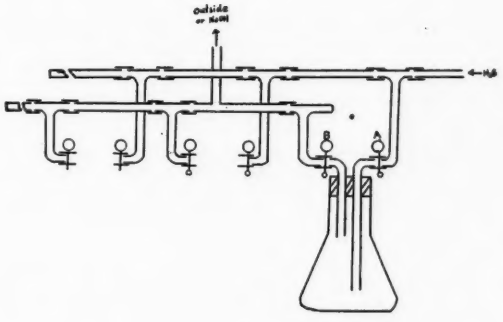
AN ODORLESS HYDROGEN SULFIDE SYSTEM*

I. LIN

Fukien Christian University, Foochow, China

The presence of hydrogen sulfide in the laboratory is not only unpleasant, but also unhealthy. To avoid



the escape of the gas into the laboratory as far as possible, we have been using our present system for several years, and have found it to be very satisfactory. The gas is generated from a Kipp's generator which has five outlets connected in parallel. The waste gas is eliminated through a common passage in a similar manner. (See diagram.) In using, both pinch clamps are opened for a few seconds and then *B* is closed. The flask is shaken until it is saturated with the gas. After practicing once or twice students can operate it without trouble. Provision must be made to fasten the tubing at short intervals so as to prevent possible breakage. It has been found that the rubber tubing used in all connections must be tied with iron wire; otherwise it will become loose in a short time.

* This system was worked out with the collaboration of Mr. I. Y. Li.

MINUTES OF THE ANNUAL BUSINESS MEETING OF THE DIVISION OF CHEMICAL EDUCATION

R. D. Reed gave a report from the Committee on Tests and Examinations, including a discussion and correlation of the results from the 1938 Coöperative Chemistry Test.

S. R. Brinkley read the report of the Committee on New Type College Entrance Board Examinations. The report was adopted as the recommendation of the Division to be sent to the College Entrance Examination Board.

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salt in the crystalline condition from the aqueous solution.

Heat the beaker and contents until the solution has been concentrated to one-third of its original volume. During the last stages of the evaporation, it will be found necessary to stir the solution in order to prevent superheating.

Cool the concentrated solution (with stirring) either by allowing tap water to flow over the lower part of the beaker, or if necessary by cooling (with stirring) in a bath of ice-water.

Filter off the crystals which separate. Wash out the last traces of salt from the beaker with 5-cc. portions of the *filtrate* making certain that *all* of the solid has been transferred to the filter. Allow the filtration to proceed as long as any appreciable separation of solid and solution occurs. Transfer the crystals from the filter to a *weighed* watch glass and spread out the solid so that it may dry readily. Allow this to dry until the next laboratory period. When the salt appears to be dry, weigh the crystals and watch glass and record this weight.

Questions and Problems: (1) What weight of disodium hydrogen phosphate was obtained?

(2) Write *one* equation representing the formation of disodium hydrogen phosphate from phosphoric acid and sodium hydroxide.

(3) On the basis of the above equation, what weight of disodium hydrogen phosphate was actually formed from the weight of *hydrogen phosphate* used (Wt. of H_3PO_4 = 0.85 × Wt. of sample)?

(4) Compare the values obtained in (1) and (3). How may the difference (if any) be accounted for?

(5) Knowing the weight of disodium hydrogen phosphate formed in the reaction and the weight actually isolated from the solution, calculate the "yield" in terms of per cent.

(6) Knowing the volume of sodium hydroxide solution required for the one-third neutralization of a given weight of eighty-five per cent. phosphoric acid, calculate the normality of the sodium hydroxide solution on the desk reagent shelf.

(7) If, in separating from the aqueous solution, disodium hydrogen phosphate crystallized with 12 molecules of water of crystallization, in what manner will this influence the results obtained in (1), (4), and (5)?

(8) Recalculate the "yield" in terms of the product having the formula, $Na_2HPO_4 \cdot 12H_2O$.

(9) Write the equations for the stepwise neutralization of phosphoric acid. Combine (add) the three steps in order to obtain one equation representing the complete neutralization.

(10) If the formula, Na_2HPO_4, represents *disodium hydrogen phosphate*, what names should be given to the salts having the formulas, NaH_2PO_4 and Na_3PO_4?

(11) If, after concentrating the solution to one-third of its original volume and cooling, no solid separated, what procedure should be used in a further attempt to secure crystals of the dissolved salt?

(12) In transferring the crystals from the beaker to the filter, the directions specify that the last traces of the salt should be rinsed out with 5-cc. portions of the *filtrate*. Why not use water for this purpose?

When the use of this experiment was first contemplated, the fact that the formation of acid salts had not yet been discussed loomed as a serious objection. Experience has shown, however, that this situation does not detract from the value of the exercise. Furthermore, it has been found that the later discussion of the nature and formation of acid salts is markedly facilitated with students who have previously carried out this particular experiment.

As was anticipated, the yields obtained by students of so limited experience were subject to wide variations. In recalculating the yield in terms of the dodecahydrate, no attempt was made to recognize the probable partial dehydration of this material.

The experiment has been used with large numbers of beginning students with uniformly satisfactory results. It is felt that while perhaps certain objectionable features must be recognized, the manner in which the experiment so obviously illustrates fundamental principles and at the same time provides a means of developing manual dexterity on the part of the student serves to recommend its use.

Although probably more costly than many experiments used in the freshman laboratory course here and elsewhere, the cost per student is by no means prohibitive. If desired, the student preparation may be collected for subsequent purification and use in the preparation of buffer solutions or for other purposes.

CORRESPONDENCE

APPARATUS FOR SPECTROSCOPIC ANALYSIS

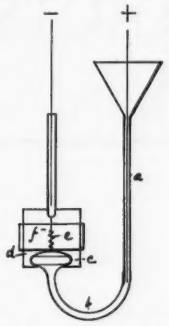
To the Editor

DEAR SIR:

Enclosed find a set-up for spectroscopic analysis, by means of which the solutions to be examined may be readily changed and the container cleaned.

It is made by bending a long-stemmed funnel *a*, as at *b*, and flaring out the lower end as at *c*. The solution containing also hydrochloric acid heaps itself up at *d*, so that a sufficient supply is present to steady the spark and prevent it from contacting and perhaps breaking the container.

The slit of the spectroscope is shown behind the spark, *e*, and should be far enough away to prevent corrosion of the metal composing it. These pieces should be made easily removable so that they may be cleaned.



The old solution is removed by running acidulated water from a reservoir, not shown, through the funnel. This spurts upward and cleans not only the funnel, but also the platinum electrode, *f*.

This set-up will definitely determine, manganese, zinc, barium, strontium, calcium, and magnesium, as well as sodium and potassium, even in the presence of each other. Any acidulated boron compound will reveal itself, by broad bands extending clear across the field, with a certainty contrasting with usual methods of flame or turmeric.

E. E. CHANDLER

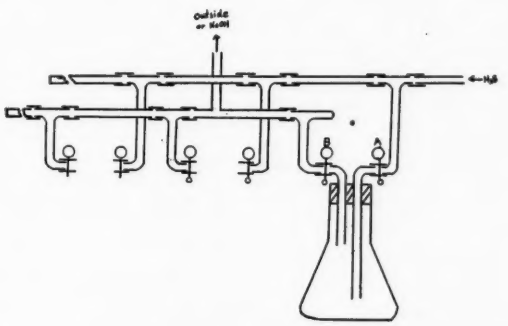
OCCIDENTAL COLLEGE
LOS ANGELES, CALIFORNIA

AN ODORLESS HYDROGEN SULFIDE SYSTEM*

I. LIN

Fukien Christian University, Foochow, China

The presence of hydrogen sulfide in the laboratory is not only unpleasant, but also unhealthy. To avoid



the escape of the gas into the laboratory as far as possible, we have been using our present system for several years, and have found it to be very satisfactory. The gas is generated from a Kipp's generator which has five outlets connected in parallel. The waste gas is eliminated through a common passage in a similar manner. (See diagram.) In using, both pinch clamps are opened for a few seconds and then *B* is closed. The flask is shaken until it is saturated with the gas. After practicing once or twice students can operate it without trouble. Provision must be made to fasten the tubing at short intervals so as to prevent possible breakage. It has been found that the rubber tubing used in all connections must be tied with iron wire; otherwise it will become loose in a short time.

* This system was worked out with the collaboration of Mr. I. Y. Li.

MINUTES OF THE ANNUAL BUSINESS MEETING OF THE DIVISION OF CHEMICAL EDUCATION

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ABSTRACTS

WILLIAM O. BROOKS
A. T. BURTSELL
R. K. CARLETON
TENNEY L. DAVIS
C. K. DEISCHER
J. HOWARD GRAHAM
B. CLIFFORD HENDRICKS

J. W. HOWARD
D. C. LICHTENWALNER
GRETA OPPE

C. M. PRUITT
LEOPOLD SCHEFLAN
A. A. VERNON
E. D. WALTER
MARY ELVIRA WEEKS
SIDNEY WEINHOUSE
G. H. WOOLLETT

KEEPING UP WITH CHEMISTRY

Acid costs (handling and storage). C. H. S. TUPHOLME. *Chem. Industries*, **42**, 399–401 (Apr., 1938).—"In any chemical process, the cost of a consumable tool, such as hydrochloric and sulfuric acids in many essential processes, is sufficient to justify exhaustive investigations into its handling and storage. Since the price of the so-called 'mineral acids' accounts for only forty to fifty per cent. of the ultimate cost of employing it, the balance is necessarily an indication of the cost of conveying, storing and distributing it about the plant.". . . .

"Rubber compositions of various kinds have been known and used long enough successfully to indicate rubber as the substance promising the solution of the problem. The early development was a composition to which sufficient rigidity or hardness was imparted to permit of the construction of the vessel itself. Such was hard rubber, which has many useful applications. It lacks, however, adaptability in application to many parts of plant requiring protection since it cannot be applied without removing the vessel, and cannot be vulcanized save in a vulcanizer, the size of which limits the magnitude of the vessel to which it is applied. Moreover, it loses rigidity and is deformed at comparatively low temperatures, and its brittleness renders it prone to fracture under variable temperatures.

"Unappreciated qualities of soft elastic rubber compositions become recognized with the development of motor tires withstanding, as many do, the mechanical stresses and abrasive action incidental to a life of ten thousand miles and more. No less important is the new rôle found for a new elastic rubber composition called "acid-rubber," now largely used in the protection of iron, steel, wood, concrete, indeed, any material of which containers of magnitude may be constructed, from the action of acid.

"This is a definite composition having chemical and physical characteristics of great inertness to the action of acid; astonishing tensile strength, little less indeed than that of the containers it protects, while its elasticity is so great as to entirely preclude fracture of the protective lining under any expansion or vibration. Unlike the 'rubber' of commerce, it can be applied to the existing irregular surfaces in its plastic condition and vulcanized where it stands without the intermediary of a 'vulcanizer,' thus lending itself admirably to application of existing plant without removal.

"Another feature of acid-rubber is its adaptability to circumstances. It may be made inert to a large range of acid and alkaline liquids, and to a great range to temperatures without deformation by appropriately adjusting its components. Its elasticity is under control from a maximum of expansibility where it will return to its original length, after being stretched ten times its length, to the hardness and brittleness of glass. At this end of its adaptability it becomes the ebonite, vulcanite, or hard rubber alluded to.

"In its soft elastic condition, such is its imperviousness that a relatively thin coating is absolutely liquid-tight; it is, therefore, relatively inexpensive and very easy to apply. Some early failures in effecting adhesion have now been overcome, and acid-rubber is chemically welded to steel, etc., so permanently as to defy removal." A. T. B.

A new method for determination of iodine in five cubic centimeters of blood or other biological material. J. F. MCCLENDON AND A. C. BRATTON. *J. Biol. Chem.*, **123**, 699–710 (May, 1938).—A microcombustion tube and distillation method for isolating the iodine in five grams of biological material is described with drawings of the apparatus.

An electrometric titration method is so refined that it seems to be one thousand times as sensitive as the starch-iodide method. E. D. W.

The influence of pimiento pigments on the color of the egg yolk of fowls. W. L. BROWN. *J. Biol. Chem.*, **122**, 655–9 (Feb., 1938).—The feeding of pimiento to fowls results in reddish orange pigmentation of the egg yolk, adipose tissue, skin, shanks, and beak. The red pigment of the pimiento is capsanthin, a dihydroxy monoketone. The pericarp contains zeaxanthin, cryptoxanthin, and β-carotene.

In order for a fowl to deposit a carotenoid in the egg yolk or fat, it appears to be necessary that at least one ring of the molecule contain one, and only one, hydroxyl group. E. D. W.

Wool fabric sterilization. ANON. *Chem. Industries*, **41**, 499 (Nov., 1937).—Workers in the Department of Agriculture are said to have discovered a process for sterilization of wool fabrics without damaging the fiber. While it has been tried as yet only under laboratory conditions, the method is believed to have practical commercial possibilities. Tests will be made in dry-cleaning and other industrial plants. A. T. B.

Hydrocarbons converted to fuel gas by new process. J. A. GUYER. *Chem. & Met. Eng.*, **45**, 326–7 (June, 1938).—Fuel gas can now be tailor-made to fit individual plant or domestic heating requirements. The hydrocarbon water gas process combines two fundamental reactions, thermal decomposition of hydrocarbon gases and vapors, and water gas reactions between hydrocarbons and steam. The reactions are carried out in a modern-type, radiant-heat tube furnace. The water is preheated by a system of heat exchangers. The hydrocarbon gases are led into the steam pipe at the point of entry to the furnace. After passing over a catalyst this mixture is converted into HWG gas. Using natural gas as the hydrocarbon the gas obtained varies from 393 to 624 B.T.U., 5.5 to 7 per cent. CO_2; 7.3 to 14.9 per cent. CO; 36.2 to 57.5 H_2; 18.5 to 47.0 per cent. saturated hydrocarbon; 1.6 to 4 per cent. unsaturated hydrocarbon. A flow diagram of the plant is given. J. W. H.

Adsorption, absorption, and condensation in recovery of solvents. C. A. BULKELEY. *Chem. & Met. Eng.*, **45**, 300–5 (June, 1938).—Three distinct methods are in use for the recovery of solvents, adsorption, absorption, and condensation. They are quite similar in principle, although they differ considerably in equipment and methods of operation.

Under the adsorption methods activated carbon is the material most used. It can take up eight to twenty-five per cent. of its weight of vapors. It is relatively high in first cost, but usually pays a handsome return on the investment.

Absorbents are usually liquids or solutions of solids in liquids. The ease of continuous operation of this method is its chief advantage.

In the methods based on condensation the vapor-laden mixture is cooled sufficiently to liquefy a portion by the lowering of the vapor tension. Two methods are used for cooling (1) passage over extended surface-cooling coils and (2) passage through a chamber wherein a refrigerated liquid is atomized by spray nozzles under pressure. The latter is considered to have the most inherent advantages. It is suitable for use in almost all cases where re-circulation in a closed system is possible, and gives a cleaner exit gas mixture than can be secured by other means. J. W. H.

HISTORICAL AND BIOGRAPHICAL

Gilding of copper among the pre-Columbian Indians. P. BERGSØE. *Nature*, **141**, 829 (May 7, 1938).—The pre-Columbian Indians of the Esmeraldas district of Ecuador gilded their copper objects in a manner not used elsewhere either in ancient or modern times. Chemical analysis shows that the copper itself is alloyed with varying amounts of gold. No mercury can be detected. "Gilding must have been done by dipping the copper into a melted gold-copper eutectic (gold with about twenty per cent. copper) the melting point of which is some 200°C. lower than that of copper; or possibly, the gold-copper alloy was applied to the copper and kept at red heat on charcoal by means of a blowpipe. The alloy will then fuse and run over the copper without the use of flux being necessary, the reducing flame securing a glowing surface free of oxide. Investigations have shown that copper has a tendency to absorb the melted alloy in the same manner as melted tin permeates copper or a zinc rod absorbs mercury. The copper nucleus thus becomes a gold-copper alloy richest in gold at the surface, the amount of gold decreasing gradually." These Indians did not practice gilding merely for decoration but to increase the hardness of the copper. "Of the thirty-five fish-hooks found, all were gilded, but not one single specimen of thirty-two sewing needles discovered. The gold which penetrates the copper fish-hooks makes the metal much harder, and hardness is the first consideration in a fish-hook."

M. E. W.

Dr. A. E. Dunstan and petroleum technology. ANON. *Nature*, **141**, 721 (Apr. 23, 1938).—The Redwood Medal of the Institution of Petroleum Technologists has been awarded to Dr. A. E. Dunstan. He was born at Sheffield in 1878. He studied at the Royal College of Science, South Kensington, at University College, London under Ramsay, and at East London College under Hewitt. At University College he collaborated with Trouton in studying the correlation between physical properties and chemical constitution. From 1905 to 1915 he served as head of the chemistry department of East Ham Technical College, after which he joined the Anglo-Persian Oil Company. In 1916 Dunstan, Lomax, and Thole dealt with the pyrogenesis of hydrocarbons and described the evolution of the cracking process and of the principles underlying it.

M. E. W.

EDUCATIONAL MEASUREMENTS AND DATA

Criteria for evaluating course-of-study materials. H. B. BRUNER. *Teachers Coll. Record*, **39**, 107–20 (Nov., 1937).—In 1937 there were 30,000 separate subject courses of study and 10,000 general courses which had been received by the Curriculum Laboratory of Teachers College. Criteria used by the Curriculum Laboratory in evaluating courses of study were as follows:

1. Philosophy
   - (*a*) Social philosophy
   - (*b*) Educational philosophy
   - (*c*) Principles of learning
2. Content
   - (*a*) Authenticity
   - (*b*) Utility
   - (*c*) Adequacy and significance
   - (*d*) Organization
3. Activities
   - (*a*) Pupil purposing
   - (*b*) Interest and needs
   - (*c*) Social values
   - (*d*) Reality
   - (*e*) Variety
   - (*f*) Approach
   - (*g*) Culminating activity
4. Evaluation of pupil's work
   - (*a*) Purposes
   - (*b*) Variety
   - (*c*) Validity
   - (*d*) Areas of growth
   - (*e*) Interpretation

Interpretive statements are included under each of the above criteria. Of 1750 science courses of study 20.2 per cent. or 353 were judged outstanding. This percentage is second highest, being exceeded only by the social studies. C. M. P.

The measurement of teaching (appraising the teacher by the continued interest of his students). H. BEAUMONT. *J. Higher Educ.*, **9**, 96–8 (Feb., 1938).—In connection with promotional policies and salary adjustments, college administrators have developed several technics for the purpose of estimating the teaching ability of an instructor, especially in comparison with his colleagues in the department. None of these methods has proved entirely satisfactory, either because of insufficient objectivity or because of too great emphasis on quantitative aspects. The former objection applies to questionnaire and rating-scale methods: the latter, to those which evaluate the results of teaching introductory courses on the basis of the number of departmental majors produced.

The method suggested in this article attempts to circumvent these objections by proposing an objective measure of the individual instructor's success in teaching elementary courses, which is expressed in terms of the quality of his students who continue their work in the department, and of the type of work which they do in advanced courses.

In brief, the proposed technic consists of a follow-up study of students in introductory courses. The simplest and most obvious measure of teaching results is obtained by computing the proportion of students in each section who take advanced work in the department after having passed the elementary course. A similar, equally crude, measure is obtained by comparing each instructor's share of the enrolment in the introductory course to the proportion of advanced students which has been derived from his "beginning" sections.

A more refined indicator of teaching effectiveness is gained by determining, in each introductory section, the proportion of students obtaining each of the different marks who continue their work in the department. This provides a means of comparing individual instructors with one another and to the departmental average in respect to the extent to which they succeed in motivating students of superior promise to take advanced work in the department.

The suggested technic provides a composite picture of the effectiveness of teaching introductory courses in terms of the number and type of students prepared for advanced work and the quantity and quality of the advanced work done by them. If used with proper precautions and interpreted with discretion, this method measures at least one of the aspects of teaching success. Its principal advantages are that the data can be obtained with little difficulty, that it possesses a high degree of objectivity, and that it affords a direct means of rating and ranking the individual instructors in a department. Its chief disadvantages are that it can be used only to evaluate introductory instruction, and that it fails to eliminate many of the extraneous factors which have made previously proposed methods ineffective. It must be stated emphatically, however, that its purpose is merely to disclose a factual situation and in no sense to attempt a causal explanation of individual differences with respect to the effectiveness of teaching introductory courses.

A. T. B.

The advantages of the "long form" of the periodic table. L. S. FOSTER. *Rept. New Eng. Assoc. Chem. Teachers*, **39**, 23–30 (Sept., 1937).—The conservatism of textbook writers causes a delay of many years after the promulgation of new theories before

they are presented to students. This conservatism accounts for the continued use of the older "short form" rather than the various modifications of the "long form" which was first suggested by Rany in 1893 and improved by Werner in 1905. The number of modifications of the periodic table that have been proposed seems to indicate that each teacher feels that it is compulsory for him to develop a new type. No table can be considered a complete representation of all the properties, but from the standpoint of teaching and from the viewpoint of the student, selection of the simplest and the least misrepresenting type would seem to be the best compromise. The table proposed by this author has the following advantages: (1) it shows plainly the number of elements in each period, (2) the non-metals are all located at the far right just to the left of the inert gases, (3) the essential metallic character of the transitional elements is not masked, (4) the inert gases are at the end of the periods instead of at the beginning, (5) interpretation of the periodicity of the elements in terms of the current theory of atomic structure is facilitated, and (6) family relationships are not obscured. Students in a study of the periodic table should be familiar with the following features: (1) periods, horizontal rows, (2) groups, vertical columns, (3) the elements that are strictly non-metallic, (4) the elements having both metallic and non-metallic forms, (5) the division of the elements into types such as inert gases, normal elements, transitional elements, rare earth elements, and (6) radioactive elements. From a discussion of the valences exhibited by the elements it becomes apparent that the relationships are quite complex and that the use of the longer expanded form of table correlates the data more adequately than the conventional type. Anyone who wishes to obtain printed cards showing the expanded form proposed by Professor Foster should send his request to William O. Brooks, Technical High School, Springfield, Massachusetts. W. O. B.

THE PHILOSOPHY OF EDUCATION

A study in the establishment of a norm in scientific attitudes and abilities among ninth-year pupils. G. C. WOOD. *Sci. Educ.*, **21**, 140–6 (Oct., 1937).—The investigator attempted to determine which members of the entering class of the James Monroe High School, New York City, practiced certain scientific attitudes or possessed certain abilities ordinarily associated with scientific attitudes. The attitudes tested for were: (1) honesty; (2) good habits of work; (3) initiative; (4) dependability; (5) openmindedness; and (6) group courtesy and coöperation. Some 2600 observations were made on 210 boys and 76 girls in 1934 and 12,825 observations on 619 boys and 410 girls in 1935 Honesty ranked lowest of traits measured. Boys excelled in initiative and girls in habits of work; both were equal in openmindedness. Repeated observations near the close of the school year indicated some gains had been made. C. M. P.

GENERAL

Industry, science and labor representatives explore silicosis prevention. *Chem. & Met. Eng.*, **44**, 430–1 (Aug., 1937).—Silicosis is a disease of the lungs in which the normal lung tissue is replaced by fibrous or scar tissue caused by breathing air containing silica dust. The development of miliary nodulation in both lungs is necessary in order to make a definite diagnosis.

Silicosis often induces tuberculosis and it is usually the tuberculosis which disables and kills the silicotic individual. The harm produced is primarily the result of chemical action in addition to possible mechanical effects of silica on the lung tissue.

The extent of damage done depends on the concentration of the silica in the air, the sizes of the silica particles, the length of exposure, and to some extent the other constituents of the atmospheric dust.

Although the primary solution of the silicosis problem is prevention it is felt that those who have contracted the disease should be compensated just as those who are injured in accidents. J. W. H.

Economics of some of the less familiar elements. H. C. MEYER. *Ind. Eng. Chem.*, **30**, 431–6 (Apr., 1938).—Although most of the less familiar elements were discovered over a century ago, their industrial application is quite recent, due to inadequate methods of recovery, ideas that their tonnage was limited and the failure to combine academic studies with industrial needs. Analyses indicate that the lithosphere (the earth's crust to a depth of ten miles) contains about 71,900 tons of Ti, 3000 tons of Zr, 456 tons of Li, 114 tons of Be per cubic mile so that even Li present to the extent of 0.004 per cent. might some day be recovered, considering that Br present to the extent of 0.0067 per cent. in sea water (455 tons per cubic mile) is being extracted. The commercial ores of Be, Li, Ti, and Zr, their location, and production are briefly discussed. For example, Zr is nineteenth in abundance, ranking ahead of Ni, Va, Cu, Zu, Pb, and B. Refined zircon sand is used to reduce coefficient of expansion in porcelain and ceramic bodies, and increase dielectric strength in spark plugs. It is also used in the manufacture of molds for cast steel and insulators in electric heating devices. D. C. L.

Nontoxic seleniferous soils. H. W. LAKIN, K. T. WILLIAMS, AND G. H. BYERS, *Ind. Eng. Chem.*, **30**, 599–600 (May, 1938).—The widespread occurrence of Se in soils has been extensively investigated and it has been assumed that the presence of considerable amounts of Se is tantamount to injury to the normal function of the soil. It is here shown that areas exist where high Se content in the soil does not produce toxic vegetation and the implied assumptions in previous work are unwarranted. Certain plants show selective adsorption of Se, while others show a limited tolerance. In Hawaii, a high Se content in the soil showed that the vegetation contained less than three parts per million Se. Millet, grown on soil containing 12 P.P.M. contained no Se, but when grown in Wabash soil containing 2 P.P.M. Se as sodium selanete, it contained 1300 P.P.M. Hawaii was the first area with a high Se content where the vegetation was consistently low in Se. A more extensive investigation in Puerto Rico gave similar results. In the United States and Canada soil containing as little as 0.2 P.P.M. produced toxic seleniferous vegetation. It had previously been shown that when sodium selenite solutions are shaken with highly ferruginous soils, the Se is rendered insoluble. In both of these sections investigated, the iron content of the soil is high. D. C. L.

On the fat of the land. ANON. *Ind. Bul. of Arthur D. Little, Inc.*, **137**, 3–4 (June, 1938).—The United States produces an almost incredible amount of animal and vegetable fats and oils, yet imported last year nearly three billion pounds to complete our requirements. We raised about seventy per cent. of our edible fat and oil requirements, importing principally coconut oil, palm oil, and olive oil. The paint and varnish industry imported largely linseed oil, tung, and perilla oil to supplement a sizable home production of linseed and soy-bean oils as well as fish oil. The soap industry uses the greater part of the inedible grade of non-drying fats and oils. For soap to be quick lathering, it must contain appreciable amounts of sodium laurate. Coconut oil is high in lauric fat. To get around the tariff on coconut oil, the soap makers have found two substitutes of importance: palm kernel oil from Africa and the Indies, and babassu oil from Brazil. Water-soluble and water-miscible oils are of great value in the processing of leather. Castor oil may be combined with sulfuric acid to make a water-soluble oily product. Enormous amounts of oils are being hydrogenated, fish oils for fine soap stock, cotton-seed oil for vegetable shortening, and in Germany petroleum as a raw material for soap. G. O.

Promising platinum find on Colorado public land. ANON. *Sci. News Letter*, **33**, 394–5 (June 18, 1938).—*The U. S. Geological*

Survey announces the discovery of promising amounts of platinum metal in the La Plata Mountains of southwestern Colorado. The platinum content of some of the ores is as high as 0.54 ounce of platinum and palladium per ton. Platinum currently sells at thirty-three dollars an ounce. Ores from this location have already produced 4500 ounces of silver and 225,000 pounds of copper and so the platinum probably can be utilized as a second by-product of the copper electro-refining process. This is the first promising platinum find in continental United States.

B. C. H.

Insecticides and fungicides. R. C. ROARK. *Chem. Industries*, **42**, 636–9 (June, 1938).—Two important developments in insecticides and fungicides during the past two decades are the great increase in the consumption of all types of these materials, especially calcium arsenate and lead arsenate, and the commercial use of new materials, especially synthetic organic compounds and products derived from derris and cube.

Insecticides are now used in the United States on a greater scale than ever before. This is due partly to the introduction of new insect pests. Some of the species that have recently gained entrance to this country and the dates of their discovery are: the oriental fruit moth and the Japanese beetle in 1916, the European corn borer in 1917, the Gulf wireworm in 1927, the strawberry fruitworm in 1929, the vetch bruchid in 1931, the European spruce sawfly in 1932, and the white fringed beetle in 1936. At present the Japanese beetle is the only one of the species combated with a significant quantity of insecticide. The principal reasons for the greater use of insecticides, however, are the great increase in numbers of species that have long been with us.

In addition to the increased use of the older insecticides, new materials are now coming into widespread use. Prominent examples are derris, cube, and pyrethrum. Derris and cube are closely related botanically, and they contain the same insecticidal constituents, of which rotenone and deguelin are the most important.

Although pyrethrum and the rotenone-bearing plants compete, more correctly they supplement each other. Rotenone and pyrethrum are highly specific in their action, and some in sects killed by rotenone are not affected by pyrethrum, and *vice versa*.

The search for new synthetic organic compounds useful as insecticides and fungicides has been vigorously prosecuted. There are many advantages inherent in the use of an organic over an inorganic chemical as an insecticide. Compounds of the highest toxicity to insects and low toxicity to man are more likely to be organic than inorganic. Synthetic organic compounds also have certain advantages over compounds of plant origin. The content of the active principle in any plant, such as rotenone in derris and cube, nicotine in tobacco, and the pyrethrins in pyrethrum flowers, is extremely variable. Furthermore, we are in the unfortunate position of having to import some of our most important insecticides of plant origin. Derris and cube come wholly from abroad. The amount of pyrethrum grown in the United States is insignificant. Moreover, chemical evaluation of these plant insecticides is difficult, and for many constituents of these plants, for example, deguelin, tephrosin, and toxicarol in derris root, no methods are available. On the other hand, the chemist always knows exactly what he is working with when he handles a synthetic product. A synthetic product of uniform strength can be produced. Moreover, synthetic insecticides can be produced from petroleum, shale oil, natural gas, coal tar, alcohols, and other raw materials which are cheap and extremely abundant in this country.

Inasmuch as about 40,000,000 pounds of lead arsenate have been consumed annually in the United States during recent years, it is obvious that a very large market awaits a successful substitute for it.

A. T. B.

RECENT BOOKS

INORGANIC COLLOID CHEMISTRY: Volume III. The Colloidal Salts. *Harry Boyer Weiser*, Professor of Chemistry at The Rice Institute. John Wiley and Sons, Inc., New York City, 1938. viii + 473 pp. 74 figs. 15 × 23 cm. $6.00 net.

This book concludes a three-volume treatise on inorganic colloid chemistry written by Dr. Weiser. Volume I (1933) deals with the colloidal elements and Volume II (1935) with the hydrous oxides and hydroxides. Volume III is concerned primarily with the theories and applications of colloidal phenomena of inorganic salts. An introductory chapter outlines briefly the general methods of formation of gels and sols of the salts. The remainder of the book is divided into five parts: Part I contains four chapters on the colloidal sulfates, carbonates, phosphates, chromates, and arsenates; Part II consists of three chapters on the colloidal halides; Part III devotes seven chapters to the colloidal sulfides of arsenic, antimony, bismuth, tin, lead, copper, silver, gold, the platinum family, zinc, cadmium, mercury, manganese, nickel, cobalt, iron, and the rarer elements in the order named; Part IV contains four chapters on the colloidal ferrocyanides and ferricyanides; and Part V devotes four chapters to the colloidal silicates. The first portion of each section presents a critical survey of the conditions of formation and the general characteristics of the individual salts and the second portion deals with the principles underlying their applications.

"Among the examples of colloid chemical behavior that have received special consideration in this volume are: the velocity of precipitation and the physical character of precipitates; the stability of sols and the mechanism of the electrolyte coagulation process; ion antagonism in colloid systems; the mutual coagulation process; adsorption on ion lattices; adsorption indicators; the color of colloids; the permeability of membranes; and the phenomena of thixotropy and rheopexy.

"The principles underlying the technical applications of the colloidal salts are illustrated by chapters on: plaster of Paris; lithopone and other sulfide pigments; Prussian blue; the colloidal halides in photography; the base-exchange phenomenon in silicate gels; the inorganic colloids of the soil; and Portland and aluminous cements."

This volume, together with the two preceding books, represents one of the most extensive critical surveys of the colloidal behavior of the elements and their inorganic compounds. The author presents a wealth of information in a clear manner and numerous citations to the original literature are given. These books will serve both as reference works and as textbooks for the study of inorganic colloid chemistry and in them will be found many suggestions for further research.

JOHN H. YOE
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AN ORIENTATION IN SCIENCE. Ten Members of the University of Rochester Faculty. *C. W. Watkeys*, Editor. McGraw-Hill Book Co., Inc., New York City, 1938. x + 560 pp. 281 figs. 15 × 23 cm. $3.50.

This is a text based on a survey course in natural science, which has been taught at the freshman level in the University of Rochester for the past ten years. Slightly less than fifty per cent. of the space is devoted to the physical sciences, with one section each on astronomy and physics, and two sections each on chemistry and geology; about forty per cent. to the biological sciences, with one section each on biology, paleontology, physiology,

bacteriology, and psychology; and about fourteen per cent. to the abstract sciences, mathematics, and logic (scientific method).

The objectives of the course seem to be contained in the following statements. "What the average person needs is not a great mass of knowledge, but an understanding of a relatively few simple principles on which all the various branches of science rest." . . . . ."Such a survey acquaints the student first of all with the scientific method of thought and procedure; secondly, it gives him a bird's-eye view of the principles and problems underlying various branches of science; thirdly, it permits him to see the relation between one field of science and others." The authors have come nearer to achieving these objectives than the writers of any other survey book of recent publication.

Ample provision has been made for the teaching of the scientific method. There is a brief introduction entitled "Growth of the Scientific Method," and a well-written section at the end, in which the subject is treated as a formal branch of logic. However, the constant use of the scientific method throughout the entire body of the book is considerably more important than these two provisions. The laws and principles of science have been developed analytically in a logical and relatively simple fashion.

Fully in accord with the general objectives, a few basic ideas which are characteristic of each branch of science have been selected, and treated with considerable thoroughness. Technical details, factual material, and applications to everyday life have not been stressed. In general, the results are very satisfactory. The presentation is clear, well-balanced, and accurate. There are, however, some instances which are not in accord with the general plan. The second section on geology contains a good deal of technical material, such as nomenclature and classification of minerals. The section on mathematics is very heterogeneous, and contains far more material than can be taught to college freshmen in the time available. In many places the treatment is rather sketchy, which is perhaps inevitable if the entire field of science is to be surveyed in a single volume.

Although each section bears the name of a separate science and is written by a different author, there is a considerable amount of integration not only between closely related sciences such as physics and chemistry, but also between less closely related sciences as chemistry and biology or physiology. The interrelations between sciences are emphasized and the unity of science is pointed out.

The book is recommended to anyone teaching a survey course in the entire field of natural science. It is meant to be used to teach science, rather than merely to talk about science. The summaries at the end of the sections help in the study of the book, and the bibliographies give suggestions for further reading. The book may serve as a basic text, but it must be supplemented with considerable material in the lectures and further reading.

THEODORE A. ASHFORD

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FERMENTE, HORMONE, VITAMINE. *Robert Ammon*, Dozent of Physiological and Pathological Chemistry, Universität Breslau, and *Wilhelm Dirscherl*, Dozent of Physiological Chemistry, Universität Frankfurt. Georg Thieme Verlag, Leipzig, 1938. xvi + 451 pp. 71 figs. RM. 32.

Part I, one hundred forty-three pages of the book deals with enzymes, of which one-fifth covers general considerations. Then Esterases, Carbohydrases, Iron-free Respiration, Dehydrogenases, Peroxidase, Catalase, Alcoholic Fermentation, Glycolysis, and a few other enzymic reactions are discussed briefly. There are four pages on the practical and therapeutic application of enzymes. In Part II, one hundred sixty-seven pages, the essay, chemistry, physiology, and therapeutics of the following hormones are discussed: Insulin, the Thyroid Hormone, the Parathyroid Hormone, the Sex Hormones, the Pituitary Hormone, the Adrenal Hormones, the Tissue Hormones, the Hormones of Questionable Specificity, and the Hormones of the Invertebrates. Part III, one hundred twenty-four pages, deals with the essay, chemistry, physiology, therapeutics of the Vitamines, and their relationship to enzymes and hormones.

It is regrettable that the book, of which the main part deals with descriptive work, contains no bibliography and that owing to its wide scope many omissions had to be made. There is occasional evidence of superficial presentation. Nevertheless, Drs. Ammon and Dirscherl have written an excellent review of the known biocatalysts, and the book may therefore be well recommended.

HENRY TAUBER

JOHNSON & JOHNSON
NEW BRUNSWICK, NEW JERSEY

STATISTICAL PHYSICS. *L. Landau*, Institute for Physical Problems, Moscow, and *E. Lifshitz*, Ukrainian Physico-Technical Institute, Kharkoff Translated by *D. Shoenberg*. Oxford University Press, New York City, 1938. viii + 234 pp. 16 × 24 cm. $6.00.

In this book, according to the statement on the jacket, "The authors present a systematic treatment of the equilibrium properties of matter in bulk, derived from its atomic structure, by the use of the general statistical method associated with Gibbs. They aim at giving in this manner an up-to-date unified presentation of thermodynamics and classical statistics. . . . Phenomena involving quantum statistics are excluded, but a very wide range of properties of matter do not require quantum statistics. . . . The exposition stresses the physical and chemical aspects of each problem rather than the mathematical. . . ."

Of course, the relation between statistical mechanics and thermodynamics has been dealt with in a number of books previously published, beginning with the classical one by Gibbs himself, and the authors have to a large extent adhered to the method used by the latter.

The titles of the different chapters are as follows: I. Introduction; II. Statistical Distribution and Entropy; III. The Thermodynamic Functions; IV. The Gibbs Distribution; V. Determination of the Thermodynamic Functions; VI. Fluctuations in Thermodynamic Inequalities; VII. The Chemical Potential; VIII. Phase Equilibrium; IX. Solutions; X. Chemical Reactions; XI. Anisotropic Bodies; and XII. Surface Phenomena.

While the treatment adopted by the authors may be adapted to certain readers, it is the opinion of the reviewer that the readers of THIS JOURNAL will find the contents rather difficult reading in many places. It would have been highly desirable if the authors could have adhered more closely to what is the generally accepted terminology in this field. For instance, they show that the entropy may be defined in terms of the logarithm of the reciprocal of a distribution function, whereas it is more commonly interpreted as the logarithm of a probability. On the other hand, they have defined very clearly the idea of partition function and its relation to the free energy of a system. The examples at the end of each chapter contain a number of interesting deductions which are in many cases given in other books as part of the text.

As will be observed from the list of chapter headings, the eleventh chapter deals with the phenomena of order and disorder in crystal lattices, a topic which has recently become of great interest in the study of the solid state. It is to be regretted that the authors have nowhere given references to literature in connection with each topic. Furthermore, the whole discussion has been kept on a highly theoretical level, and no actual practical examples are given of the applications of the generalizations which are deduced throughout the volume.

In spite of these deficiences in the contents, the book should prove valuable to those readers who would like an introductory treatment to a more advanced treatise such as that of R. H. Fowler's.

SAUL DUSHMAN

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TRADE ANNOUNCEMENTS

A New Quartz Ultra-violet Lamp

The *Hanovia Chemical and Manufacturing Co., Newark, N. J.*, announces the perfection of a new and more efficient lamp for producing intense ultra-violet radiations. This is a self-lighting quartz mercury vapor arc. It operates from alternating current through a reactive transformer. The apparatus is small, of compact construction, inexpensive to purchase and maintain.

Measurements show an ultra-violet intensity of 6000 microwatts of radiations of 3130 Ångstrom units and shorter at a distance of three inches. The spectrum is characteristic of the high pressure quartz mercury arc. The quartz burner is "C" shaped, the useful length of the arc is $1^1/_2$ inches by $^1/_2$ inch in width. The burner can be operated in any position and is not affected by shocks or jars unless these are of sufficient intensity to fracture the quartz tube.

The "S" 100 burner, as it is termed, uses only about 100 watts of power, but is a very efficient device. Lifetime tests show that after a thousand hours of service the burner still provides an average of seventy-five per cent. of initial intensity.

The new lamp also differs from the old type of mercury arc in that there are no pools of fluid mercury. Only a small amount of mercury is in the tube and this is all vaporized when the burner is in operation. The burner envelope is made of clear fused quartz which has a far greater efficiency of transmitting ultra-violet radiations than even the best of expensive chemical glass. Quartz also does not readily exhibit the solarizing characteristics of glass. Fused quartz withstands temperatures where glass would melt. The new lamp has many commercial uses in addition to being a therapeutic source of ultra-violet radiations for home use.

New Direct-Set Indicating Controller

C. J. Tagliabue Mfg. Co. in *Brooklyn, N. Y.*, announce the development of a new Direct-Set Indicating Controller, Model No. 9-TIC for temperature and Model No. 9-PIC for pressure.

The manufacturer states that these instruments are designed for ruggedness and operating convenience and are presented in a strong weather-proof aluminum case finished with black enamel and chromium. The distinctive modern style of these new instruments is in pleasing agreement with advance mechanical construction which give strength and character to any equipment set-up. Basically, all the latest TAG Developments include the interchangeable calibrated tube system, safety link for range protection, pointer arm brackets with bearings at each end, and all important parts of stainless steel.

These Direct-Set TAG Indicating Controllers can be supplied in two types: "On-Off" or "Throttling." "On-Off" Controller will open the diaphragm valve if the temperature is slightly below the setting point, and will close the valve if the temperature rises slightly above. The Throttling type is identical to the "On-Off" design except for the flapper mechanism. This instrument utilizes an adjustable flapper which provides a convenient and exacting sensitivity adjustment from hair line to one hundred per cent. throttling range.

The TAG "On-Off" Controller and the TAG Throttling Controller have the Direct-Set Feature. Both the white control pointer and the red setting pointer indicate on the $5^1/_2$" graduated scale, thus offering an ideally clear, direct reading for checking control performance.

The company has published a new bulletin, No. 1175, which describes both the "On-Off" and Throttling types of this TAG Direct-Set Indicating Controller Line, and a copy will be sent free upon request.

New Laboratory Apparatus Catalog

The *Will Corporation of Rochester, New York*, have announced publication of their new catalog no. 5 of laboratory apparatus. This book contains over 900 pages of text and illustration and lists more than 13,000 items and sizes. Several hundred items are shown in this catalog for the first time and it is the only laboratory apparatus catalog to show correct Pyrex glassware prices, packages, and discounts.

A special feature of this catalog is the ease with which items can be located. Heading each page is a running index of the page contents. In addition, more than 100 columns of general index with complete cross-references permit instant location of any wanted item. The type faces and page arrangements make it extremely easy to read and most of the illustrations are entirely new. The book is bound in green cloth with gold lettering and is available to established laboratories on request.

Absorption Cells for Quantitative Photometric Analyses

By a new process developed in the laboratories of the *American Instrument Company, Silver Spring, Maryland*, absorption cells are now available with optical flats fused in place, thus eliminating the disadvantages of cells with flats cemented in place.

The windows of these cells are flat over their entire area to within 6 wave-lengths after fusing. Parallelism of the liquid-glass interfaces are ± 0.025 mm. in standard cells, and ± 0.01 mm. in high precision cells. Parallelism of the faces of each window is ± 10 min.

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New Aluminum Salt for Water-Repellent Treatment Available

In order to provide a highly concentrated source of soluble aluminum for the water-repellent treatment of textile fabrics, the *Niacet Chemicals Corporation, 4709 Pine Avenue, Niagara Falls, New York*, offers two new soluble aluminum acetate salts under the trade-names, "Niaproof" and "Niaproof" B.

"Niaproof"* contains thirty-seven to thirty-nine per cent. of alumina as Al_2O_3 and dissolved readily in water to form solutions of any desired concentration. The pH of "Niaproof" solutions, an important factor to consider when compounding any aluminum salt with wax emulsions, varies from 5.1 at thirty-two per cent. concentration to 5.4 at one per cent. concentration. If solutions of lower pH are desired, the addition of small amounts of Glacial Acetic Acid will give solutions as low as pH 3.6.

"Niaproof" B is a more basic type of aluminum acetate salt containing thirty-five per cent. of alumina as Al_2O_3. Solutions are prepared by dissolving in almost boiling water with violent stirring. Such solutions have a pH range of from 4.7 at thirty-two per cent. concentration to 4.8 at one per cent. concentration, and lower values may also be secured by the addition of Glacial Acetic Acid.

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